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# Northern shrimp (*Pandalus borealis*) off Baffin Island, Labrador and northeastern Newfoundland – second interim review

# Deuxième examen provisoire de l'état des stocks de crevette nordique (*Pandalus borealis*) au large de l'île Baffin, du Labrador et du nord-est de Terre-Neuve

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**Abstract**

Updates of northern shrimp (*Pandalus borealis*) assessments were performed for Division 0B, Division 2G, Hopedale + Cartwright Channels and Hawke Channel + Division 3K, which correspond to shrimp fishing areas 2, 4, 5 and 6, respectively. Status of the resource in each area was inferred, in part, by examining trends in commercial catch, effort, catch per unit effort, fishing pattern and size sex age composition of the catches. A multispecies research trawl survey conducted in 2001 provided information on distribution, abundance, biomass, size sex composition and age structure of shrimp in Hopedale + Cartwright Channels and in Hawke Channel + Div. 3K. These findings were compared with results of previous surveys in these areas.

Catch rates by offshore vessels in Hopedale + Cartwright, and Hawke + 3K remained relatively stable at a high level. The research survey in the fall of 2001 showed that abundance and biomass estimates remained high in both areas with indications of recent increase. Catch rates in Div. 2G have increased since 1995, while those in Div. 0B have varied at a high level since 1996.

The shrimp resource in Hawke Channel + Div. 3K is currently healthy with high abundances of males and females. Residual female biomass and stronger 1997 and 1998 year classes should buffer the effects of a weak 1996 year class for the next few years. Biomass and abundance of both males and females increased within Hopedale + Cartwright over the period 1999 – 2001, however, due to operational problems, the survey in this area occurred two months later than usual, did not cover the southeastern portion of Div. 2H and had to be conducted, in part, by a new vessel. The relative influences of these factors upon the survey results are unknown. Current status and prospects in Div. 2G are unknown because the lack of a research survey in 2001 precluded evaluation of the spawning stock, the level of exploitation and recruitment. Similarly, the lack of a research survey into Div. 0B creates uncertainty in understanding the stock status, distribution, delineation and exploitation level, therefore, prospects in 0B are unknown.

**Résumé**

Nous présentons des mises à jour des évaluations des stocks de crevette nordique (*Pandalus borealis*) de la division 0B, de la division 2G, des chenaux Hopedale et Cartwright, et du chenal Hawke et de la division 3K, qui correspondent respectivement aux zones de pêche de la crevette 2, 4, 5 et 6. Nous avons examiné les tendances des prises commerciales, de l'effort, des prises par unité d'effort, des patrons d'exploitation et de la répartition des prises par taille, sexe et âge pour déduire dans une certaine mesure l'état de la ressource dans chaque zone. Un relevé de recherche plurispécifique au chalut effectué en 2001 a permis de recueillir des renseignements sur la distribution, l'abondance, la biomasse, la répartition des prises par taille et par sexe, et la structure des âges de la crevette peuplant les chenaux Hopedale et Cartwright et le chenal Hawke et la division 3K. Nous avons comparé ces résultats à ceux issus de relevés précédents effectués dans ces zones.

Les taux de prises réalisés par les bateaux hauturiers dans les chenaux Hopedale et Cartwright, ainsi que dans le chenal Hawke et 3K, très élevés, sont demeurés relativement stables. Le relevé de recherche de l'automne 2001 a révélé que l'abondance et la biomasse estimatives dans les deux zones demeurent élevées et donnent des signes d'avoir augmenté récemment. Les taux de prises dans 2G ont augmenté depuis 1995, tandis que ceux obtenus dans 0B ont varié depuis 1996, tout en demeurant élevés.

La ressource en crevette du chenal Hawke et de la division 3K est en bon état à l'heure actuelle, les mâles et les femelles étant très abondants. La biomasse résiduelle de femelles et des classes d'âge 1997 et 1998 plus abondantes devraient amortir les effets d'une faible classe d'âge 1996 au cours des prochaines années. La biomasse et l'abondance des mâles et des femelles dans les chenaux Hopedale et Cartwright ont augmenté au cours de la période 1999-2001, mais à cause de problèmes opérationnels, le relevé dans ce secteur a été effectué deux mois plus tard que d'habitude, n'a pas couvert la partie sud-est de la division 2H et a dû être réalisé en partie avec un nouveau navire. Les influences relatives de ces facteurs sur les résultats du relevé sont inconnues. L'état actuel et les perspectives de la ressource dans la division 2G sont inconnus du fait que l'absence d'un relevé de recherche en 2001 a écarté la possibilité de faire une évaluation du stock reproducteur, du niveau d'exploitation et du recrutement. De même, le fait qu'un tel relevé n'ait pas été effectué dans la division 0B infirme notre compréhension de l'état, de la distribution, des limites et du niveau d'exploitation de ce stock et ne nous permet pas d'établir quelles sont ses perspectives.

## INTRODUCTION

The Canadian fishery for northern shrimp (*Pandalus borealis*) from southern Davis Strait (Division 0B) to the northeast Newfoundland Shelf (Division 3K) has been regulated within three-year, integrated management plans since 1991. The 2000 – 2002 plan was based, in part, on a Stock Status Report (DFO, 2000) produced during a full resource assessment that included detailed analyses of commercial fishery and research survey data up to and including 1999. Interim reviews and updates are performed routinely to monitor any changes in resource status within the multi-year term and, if necessary, to provide a basis for adjustments to the total allowable catches (TAC's). This research document provides the information considered during the second interim review within the current plan.

The assessment update, conducted in March 2002, included four shrimp fishing areas (SFA's): Hawke Channel + NAFO Division 3K (SFA 6), Hopedale + Cartwright Channels (SFA 5), Division 2G (SFA 4) and Division 0B (SFA 2). *Pandalus borealis* in Divisions 0A (SFA 1), 3L and 3M (SFA 7), assessed annually by Scientific Council of NAFO, were not included. Also, *Pandalus montagui*, which are fished commercially as the main species within SFA's 2, 3 and 4 west of $63^0$ W and occurs as by-catch elsewhere, were not considered because there was no new information relevant to distribution, stock size or exploitation levels to assess resource status. Therefore, there was no basis for revising the TAC for this species in SFA's 2, 3 and 4, west of $63^0$ W from its current level (1200 ton TAC, but a 3800 ton catch limit).

## MATERIAL AND METHODS

### Commercial fishery data

Catch Per Unit Effort (CPUE) was calculated by year for each SFA and used as an indicator of change in the fishable stock over time. Prior to 2001, models made use of vessel logbook records. Models derived for the present assessment made use of observer datasets because we wanted to present models that account for the usage of windows (escape openings). The usage of windows is captured in the observer dataset but not in the logbooks. Records indicating more than one trawl and or the presence of windows were omitted from these calculations. Raw catch effort data for each SFA were standardized by multiple regression, weighted by effort, in an attempt to account for variation due to factors such as year, month, area and vessel. In order to track only experienced fishers, and to reduce the number of estimated parameters, vessels with less than two years of experience were excluded from the analyses. This increased our confidence when interpreting results.

Final models included all significant class variables with the YEAR effect used to track the trend in stock size over time. The difference (or similarity) between the 2001 YEAR parameter estimate and those of previous years was inferred from the output statistics.

Logbook and observer catches were plotted using ACON (Black, 2001). The area fished each year was divided into 10 min. X 10 min. cells, catches were aggregated by cells, aggregated catches were organized into a cumulative percent frequency (cpf). The cpf was used to determine the number of cells accounting for 75% of the catch each year (Swain and Morin, 1996). The plots and quantification of spatial coverage were used in describing changes in fishing patterns and practices that might affect CPUE interpretations.

Sizes of male and female shrimp in the catches were obtained from samples taken by observers on both large (>500 t) and small (<=500 t; LOA<100') vessels. Samples were adjusted upward to set, month and year for each SFA to derive a series of annual catch-at-length compositions. Age structure was inferred by identifying prominent year-classes (modes) within composite length distributions and tracking their developments over time. These samples are considered representative throughout much of the time series. The small vessel fleet began harvesting shrimp during 1997. Prior to 2000, it was felt that observer coverage and number quality of samples were not sufficient for scientific purposes. Therefore, the 1997 – 1999 commercial length distributions, based on sampling from only large vessels (>500 t), might not be representative of catch-at-length and age from both fleets.

**Research survey data**

Shrimp abundance, biomass, maturity and carapace length data have been collected since autumn 1995, as part of the Canadian multispecies surveys conducted using the CCG Wilfred Templeman and CCG Teleost. Fishing sets of 15 minute duration and a towing speed of 3 knots were randomly allocated within strata, to depths of 1500 m. The surveys have a target of one sample per 350 sq. Nmi, with a minimum of two samples per stratum. Both vessels used a Campelen 1800 shrimp trawl with a codend mesh size of 40 mm and a 12.7-mm liner. SCANMAR sensors estimated that the mean wingspread was 16.8 m. Details of the survey design and fishing protocols are outlined in Brodie (1996) and McCallum and Walsh (1996).

Survey coverage, within Hawke Channel + Div. 3K (SFA 6), has been extensive in areas where shrimp occur and reliable estimates of distribution, abundance and biomass have been obtained each year. Farther north, survey coverage has not been sufficient to resolve the highly patchy distribution of shrimp. During 1999, it was decided that future surveys would extend to the top of 2H in alternate years. During intervening years, the survey would extend to the top of Div. 2J. NAFO divisions 2HJ3K were surveyed during 2001. However, due to

vessel problems, Div. 2H was surveyed during December rather than October. The CCG ALFRED Needler rather than the CCG Teleost surveyed much of Div. 2H and approximately ten (10) planned fishing locations were not occupied in the southeastern corner of Div. 2H. A research survey has not been conducted in Div. 2G since 1999 and has never been conducted in Div. 0B.

Shrimp were frozen and returned to the Northwest Atlantic Fisheries Centre where identification to species and maturity stage was made. The maturity of the shrimp was defined by five stages:

males;
transitionals;
ovigerous;
primiparous females;
and multiparous females

as defined by Ramussen (1953), Allen (1959) and McCrary (1971). During the fall surveys, most females are ovigerous. No attempt was made to remove the eggs, therefore, it was not possible to identify whether ovigerous animals were first time or multiple year spawners.

Oblique carapace lengths (0.1 mm) were recorded while number and weight per set were estimated. Shrimp abundances were combined into 0.5 mm carapace length bins for length based analysis.

Abundance and biomass estimates with Monte Carlo confidence intervals were calculated using a non-parametric method known as OGive MAPping (OGMAP) (Evans *et al.*, 2000). Abundance at length and sex were also derived using this technique. Age structure from survey data was determined by identifying year-classes within the composite length frequency distributions.

Exploitation indices were calculated by dividing total catch by each of the following previous fall estimates: lower 95% confidence limit of the biomass estimate and point estimates of spawning stock biomass (SSB), and fishable biomass. The fishable component of the population was defined as being all males greater than 17.5 mm CL and all females. Fishable male biomass was determined by converting abundances to biomass using the autumn length weight regression:

$Wt. = 0.000838Lt^{2.929}$ (Skúladóttir, 1997).

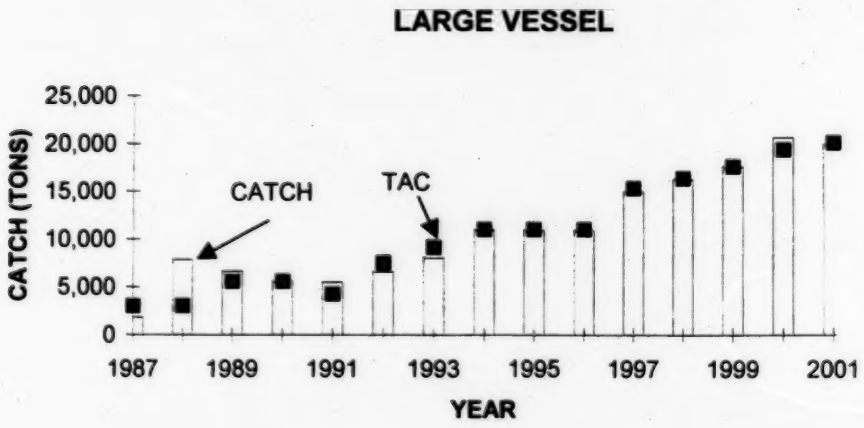
Female biomass was determined using OGMAP. Female and male (> 17.5 mm) biomasses were added to obtain fishable biomass.

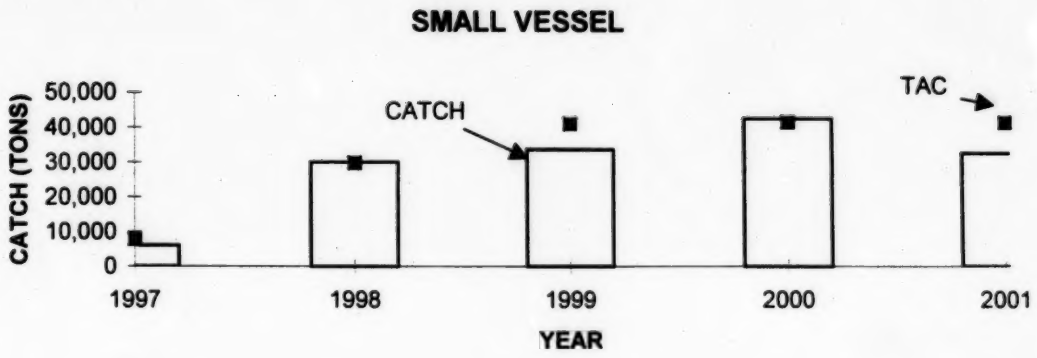
## ASSESSMENT OF SHRIMP IN HAWKE CHANNEL+DIV. 3K (SFA 6)

### FISHERY DATA

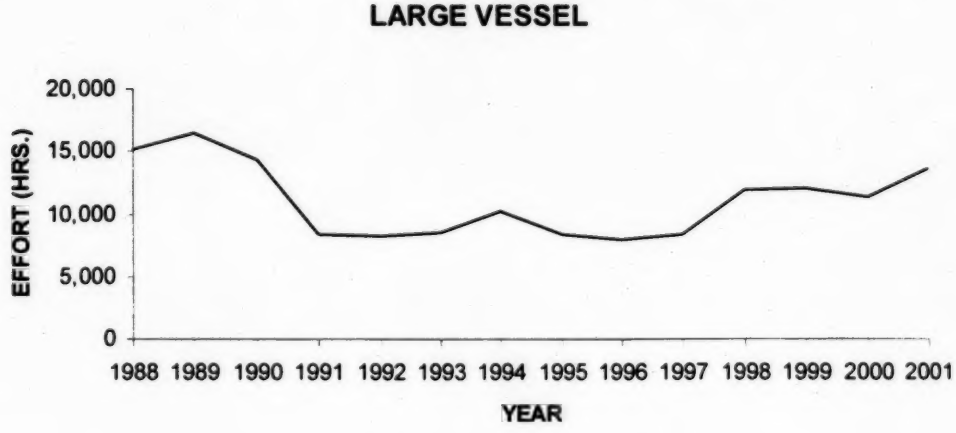
#### Catch and effort

Catches increased from about 1,800 t in 1987 to more than 7,800 t in 1988 and ranged between 5,500 and 8,000 t from 1989 to 1993, inclusive. The TAC for SFA 6 in the 1994 - 1996 Management Plan was set at 11,050 t annually and catches increased to 11,000 t. The TAC for 1997, the first year of the 1997 - 1999 multi-year plan, was raised to 23,100 t as a first step toward increasing exploitation within a healthy resource. Most of the increase was reserved for the development of a small vessel component. Catches in 1997 were estimated to be approximately 21,200 t, about 6,100 t due to vessels less than 100 feet. Despite the large increase in catch, relative exploitation in 1997 remained low and the TAC for 1998 was increased again by 100% to 46, 200 t. Catches exceeded 46,300 t with the expanding small vessel fleet reporting about 30,000 t. The 1999 TAC was increased (27%) to 58,632 t. Due to operational problems, small vessel catches were 7,400 t short of their 41,029 t quota, whereas the large vessel fleet took 17,600 t. In 2000, the TAC was increased only by 5% to 61,632 t. Catches in 2000 totaled 63,266 t, 20,615 t by large vessels and 42,651 t by small vessels. The 2001 TAC remained at 61,632 t, of which 20,000 t were taken by the large vessel fleet while only 32,700 t were taken by the small vessel fleet. The small vessel fleet did not take its entire quota because there was a glut in international the market for peeled, frozen shrimp. Therefore, there was an industry imposed shrimp closure. The closure affected the small vessel fleet and lasted from the beginning of July until the end of September.

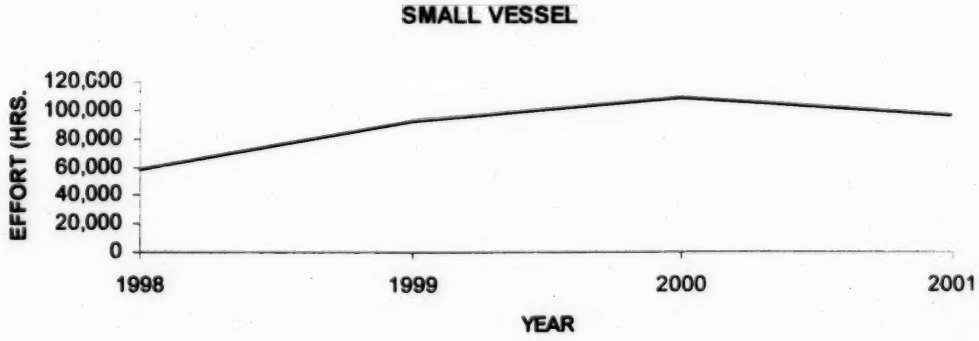





Fishing effort (hours fished = total catch cpue) estimated for large vessels declined from 1989 to 1991, stabilized to 1997 and increased thereafter with increases in TAC.



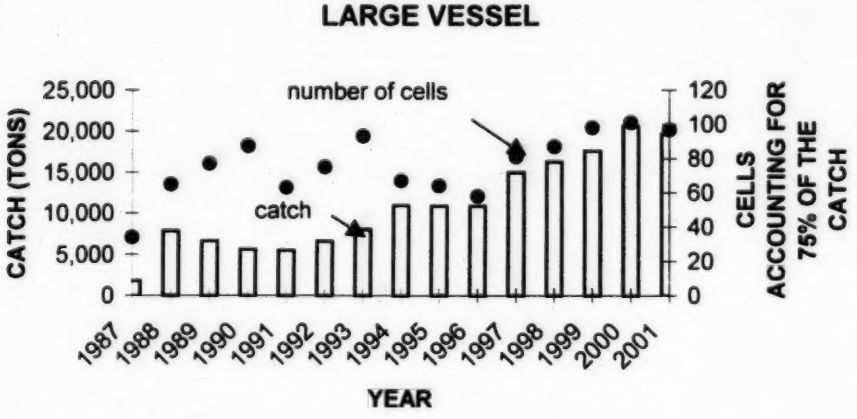

Similarly, effort for the small vessel fleet increased with the increasing TAC.



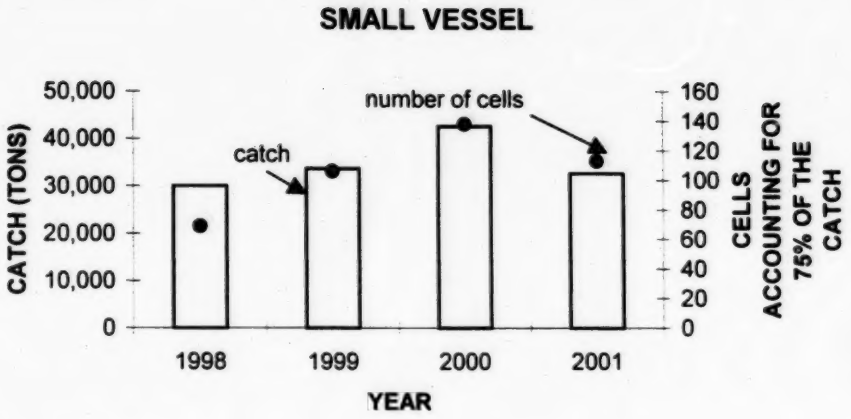
The fishery by large vessels primarily occurs during the first five months of the year (Fig. 1) whereas small vessels fish from late spring to early fall (Fig. 2). The latter figure indicates that the small vessel fleet reduced it's activity during July – September, rather than completely close. Vessels based in Div. 2J were fished throughout this period (G. Chidley, pers. comm.).

The large vessel fleet fished along the shelf edge during the early 1990's (Fig. 3). The fishery extended as far south as the St. Anthony Basin and Funk Island Deep because of the establishment of exploratory areas on the shelf slope in 1992 and 1993, and the discovery of dense concentrations of shrimp within these areas. During the 1994 – 1996 period, both catch and effort declined markedly in St. Anthony Basin and Funk Island Deep. The 1994 – 1996 management plan allowed flexibility to fish anywhere within the combined management area. Since then, the large vessel fleet has taken most of their catch from Hawke Channel and within the 500 m contour along the northern portion of SFA 6.

These changes in fishing pattern are reflected in the change in number of cells accounting for 75% of the catch. During 1993, the cell count is high at a time when an exploratory fishery was established in the south. Between 1994 and 1996, the number of cells declined as catch and effort declined in St. Anthony Basin and Funk Island Deep. The presence of sea-ice also affected the accessibility of certain fishing areas. After 1996, the index increased with catch indicating that fishable biomass was spread over a broad area.




The small vessel fishery concentrated in Hawke Channel, St. Anthony Basin and southern Div. 3K in 1997. Effort decreased within St. Anthony Basin during 1998, but has since expanded to cover much of the management area (Fig. 4).



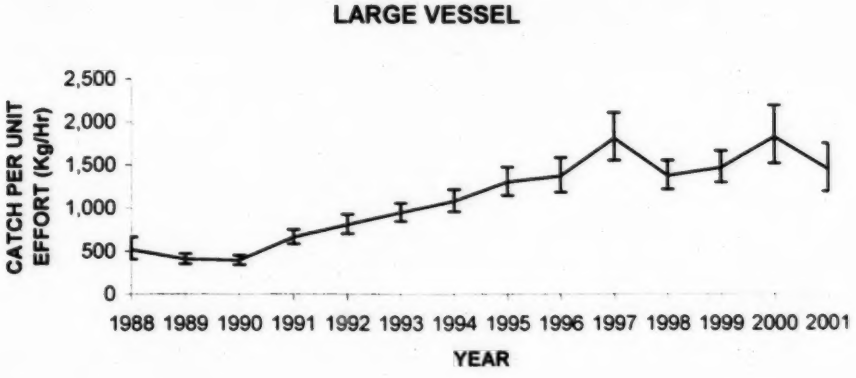

**Catch per unit effort (CPUE)**

Annual CPUE's for large vessels (single trawl, no windows) increased steadily from 1990 to 1995 and have since stabilized at a high level. The CPUE data were analyzed by multiple regression for year, month, vessel and area effects to standardize the catch rates (Table1). With the exception of 1997, the 1995 - 2000 CPUE estimates were similar to the 2001 ($P > 0.05$) estimates. Values prior to 1995 were significantly lower than the 2001 estimate ($P < 0.05$).

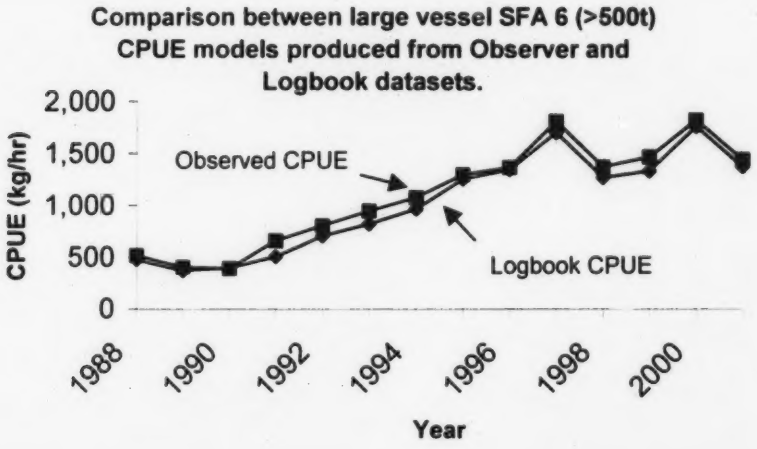
Catch rates are being maintained at a high level while the fishery covers a broad geographic area suggesting that the stock is healthy.

The following indicates the 95% confidence intervals around each CPUE estimate using observed data.

A relatively low percentage of the catch was observed during 2000 and 2001 which could account for the broad 2000 and 2001 confidence intervals. These years made use of only Newfoundland and Quebec observer data.

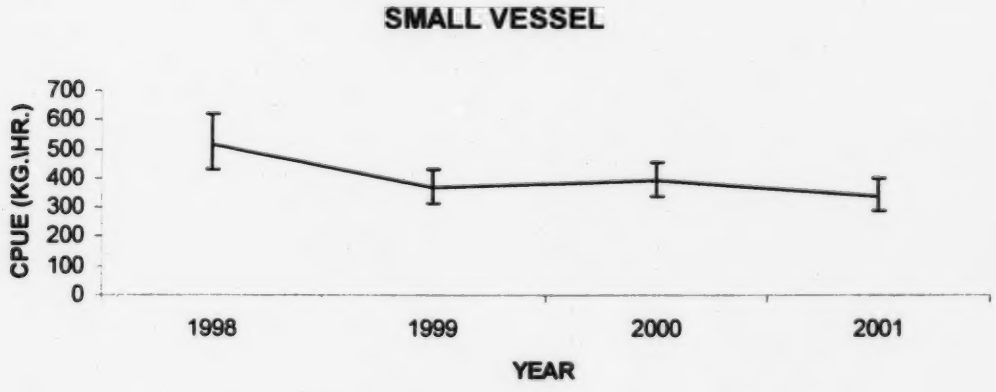


The logbook dataset included data from all large vessels fishing for northern shrimp off Baffin Island, and the coasts of Labrador and northeastern Newfoundland. The logbook CPUE model is similar to that created from observer data. Therefore, one may conclude that the observer dataset is representative of the large vessel fishery.




Historic fishery data for this management- assessment area are summarized in Table 2.

Tables 3 and 4 provide the limited small vessel catch statistics and the CPUE model output. The 1999 catch rate was similar to the 2001 estimate ($P>0.05$), however, the 1998 and 2000 CPUE estimates were significantly higher than the 2001 estimate ($P<0.05$). The time series covers only four years therefore one should not try to interpret the significance of the downward trend in small vessel CPUE.

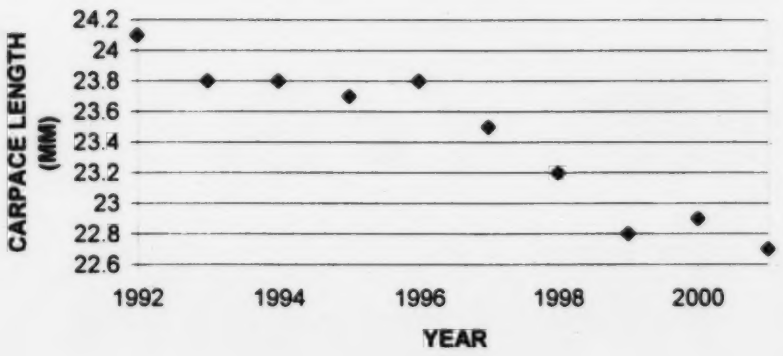


**Size composition**

Catch-at-length, estimated from samples taken by observers on large vessels, showed dominance of the female component around 23 - 24 mm carapace length (CL) in most years (Fig. 5). The relatively strong 1991 year-class, first appeared at approximately 16 mm in 1994 (age 3), dominated the male component at 18 mm in 1995 (age 4) and at 20 mm in 1996 (age 5). In 1997, at age 6, most were female. Likewise, the 1993 year-class was well represented at 16 mm in the 1996 samples and at 18 mm in 1997 and 20 mm in 1998. The 1994 year-class dominated the male component during 1999 while the 1995 year -class dominated in 2000. In 2001, the 1997 year-class (age 4 – 18 mm) dominated catches of males while the 1996 year-class (age 5 – 20 mm) appeared weak.

Mean size of females and the size at sex inversion declined slightly in recent years (Fig. 5), indicating a possible change in growth maturity schedule within the area. Although smaller females carry fewer eggs, reproductive potential has been maintained by the continued high abundance of females.

**TRENDS IN AVERAGE CARAPACE LENGTH AMONG FEMALES TAKEN IN THE LARGE VESSEL FISHERY**




It was felt that small vessel observer protocols prior to 2000 were not sufficient to collect representative length frequencies. Therefore, the analysis of shrimp length frequencies from the small vessel sector (Fig. 6) begins with 2000 samples. Males ranging in carapace length from 10 to 23.5 mm dominated the 2000 samples. The first clear mode appeared at 14 mm (1998 year-class – age 2), followed by a dominant mode at 17 mm. The latter shrimp were thought to be three years old (1997 year class). The relatively weak 1996 year-class is obscured within the 19 - 22 mm size range. The largest males (> 19 mm) and smallest females (< 22 mm) are thought to belong to the 1995 year-class. The

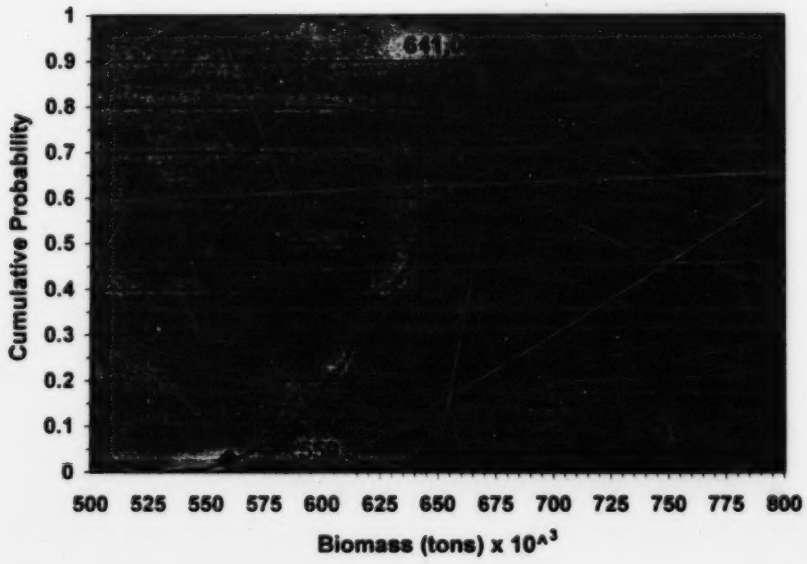
2001 length frequencies do not show clear male modal structure possibly due to low sample sizes.

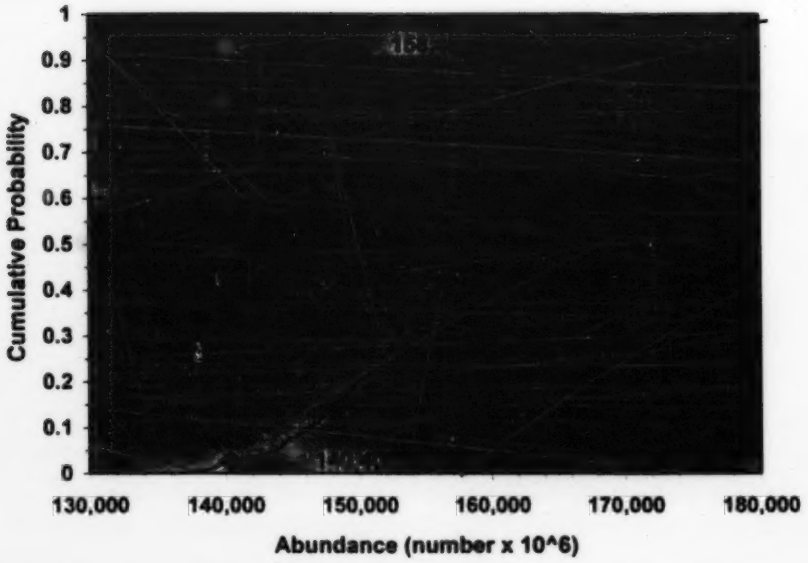
As illustrated in Fig. 6, males dominated the inshore catches. This contrasts the offshore catches that were dominated by females.

## RESEARCH SURVEY DATA

### Stock size

Results of the 2001 fall multispecies research survey showed that shrimp continue to be widely distributed and abundant throughout Hawke Channel + Div. 3K (Figs. 7 & 8). Minimum trawlable biomass was estimated at 641,000 t and abundance at 158 billion animals, the highest in the series. Monte Carlo confidence limits reflect the high level of precision around the estimates from this area.



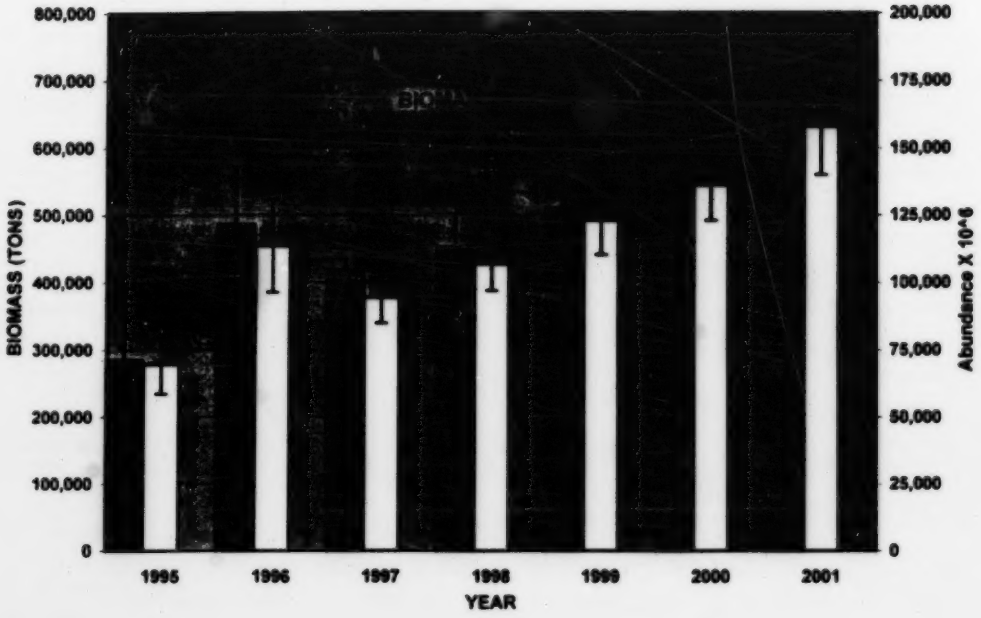



Biomass abundance estimates and their 95% confidence intervals from 1995 to 2001 are compared in the following table and figure.

**Northern shrimp stock size estimates in Hawke+3K (SFA 6)[1] from fall research trawl surveys - offshore, 1995 - 2000.**

| | Biomass (tons) | | | Abundance (numbers x $10^{-6}$) | | | Survey |
|---|---|---|---|---|---|---|---|
| | Lower C.I. | Estimate | Upper C.I. | Lower C.I. | Estimate | Upper C.I. | Sets |
| 1995 | 234,600 | 284,700 | 353,200 | 58,710 | 69,530 | 83,200 | 195 |
| 1996 | 408,600 | 486,800 | 572,900 | 96,310 | 113,400 | 131,200 | 238 |
| 1997 | 371,500 | 418,900 | 462,500 | 84,950 | 94,315 | 102,600 | 232 |
| 1998 | 413,100 | 453,150 | 501,500 | 96,960 | 106,700 | 118,800 | 234 |
| 1999 | 457,500 | 510,900 | 569,600 | 110,200 | 122,900 | 137,900 | 233 |
| 2000 | 510,400 | 565,400 | 630,900 | 123,100 | 136,150 | 150,700 | 241 |
| 2001 | 560,000 | 641,000 | 727,000 | 140,000 | 158,000 | 177,000 | 252 |

**[1] Area compared each year = 171,048.5 sq. km.**




Inshore strata along the northeast Newfoundland coast were not sampled in 1995 or 1999. Therefore, the analyses were confined to the offshore strata for comparative purposes. When sampled, inshore areas generally produced low catches of shrimp that did not contribute substantially to the biomass/ abundance estimates.

Point estimates for biomass (abundance) increased from about 285,000 t (69 billion) in 1995 to 487,000 t (113 billion) in 1996 but declined to 419,000 t (94 billion) in 1997. Since then, estimates increased steadily to 641,000 t (158 billion) in 2001. The lower 95% confidence intervals for the biomass indices averaged 453,500 t (about 109 billion animals) during the 1996 - 2001 period.

The fact that confidence intervals are relatively tight suggests that the stock is spread throughout the survey area. This is in agreement with the areal index used to describe trends in the commercial fishing data.

Exploitation indices were determined using the following three methods:

1) catch the lower confidence limit of the previous autumn's biomass estimate;
2) catch the previous autumn's spawning stock biomass (SSB – point estimate) and
3) catch the previous autumn's fishable biomass (point estimate).

| Year | Catch (large + small vessel) (t) | Lower 95% C.I. of Total Biomass (t) | SSB (t) | Fishable Biomass (t) |
|---|---|---|---|---|
| 1995 | | 234,600 | 146,500 | 200,795 |
| 1996 | 10,923 | 408,600 | 197,450 | 348,456 |
| 1997 | 21,018 | 371,500 | 176,900 | 335,770 |
| 1998 | 46,337 | 413,100 | 209,750 | 397,818 |
| 1999 | 51,260 | 457,500 | 253,850 | 440,365 |
| 2000 | 63,266 | 510,400 | 291,100 | 470,341 |
| 2001 | 52,594 | 560,000 | 342,000 | 533,812 |

| Year | Catch Lower C.I. of Total Biomass | Catch SSB | Catch Fishable Biomass |
|---|---|---|---|
| 1996 | 0.05 | 0.07 | 0.05 |
| 1997 | 0.05 | 0.11 | 0.06 |
| 1998 | 0.12 | 0.26 | 0.14 |
| 1999 | 0.12 | 0.24 | 0.13 |
| 2000 | 0.14 | 0.25 | 0.14 |
| 2001 | 0.10 | 0.18 | 0.11 |

Each of these methods indicate that exploitation increased between 1997 and 1998 consistent with the increase in catches during this period. Exploitation remained stable during 1998 – 2000 as both catch and biomass increased. Exploitation indices decreased in 2001 because the total catches decreased at a time when biomass was increasing. It should be noted that actual exploitation rates are unknown but are likely lower than indicated above because the OGMAP indices are believed to be underestimates (i.e. catchability of the survey gear is unknown but believed to be < 1).

Biomass/ abundances of males increased from 241,000 t (73 billion animals) in 1997 to 300,000 t (109 billion animals) during 2001. Similarly, the female stock increased from an estimated 176,900 t (21 billion) in 1997 to 342,000 t (50 billion) in 2001.

| Stock size estimates for male and female shrimp in Hawke+3K (SFA 6) from fall research trawl surveys – offshore, 1995 - 2000. | | | | | | |
|---|---|---|---|---|---|---|
| | Biomass (t) | | | Abundance (numbers x $10^{-6}$) | | |
| | Males | Females | Total | Males | Females | Total |
| 1995 | 137,200 | 146,500 | 283,700 | 51,105 | 18,300 | 69,405 |
| 1996 | 288,250 | 197,450 | 485,700 | 90,070 | 23,180 | 113,250 |
| 1997 | 241,050 | 176,900 | 417,950 | 72,720 | 21,390 | 94,110 |
| 1998 | 244,800 | 209,750 | 454,550 | 77,015 | 29,745 | 106,760 |
| 1999 | 258,400 | 253,850 | 512,250 | 88,440 | 34,270 | 122,710 |
| 2000 | 276,200 | 291,100 | 567,300 | 96,575 | 39,535 | 136,110 |
| 2001 | 300,000 | 342,000 | 642,000 | 109,000 | 49,900 | 158,900 |

**Stock composition**

Length distributions representing abundance-at-length from the 1996 – 2001 surveys are compared in Fig. 9.

Abundance estimated from the 2001 survey data was dominated by a broad size range of males from 13 to 20 mm carapace length believed to include the 1997, 1998 and 1999 year-classes (ages 4, 3 and 2 respectively). The 1997 year - class was evident near 18 mm, while the 1998, 1999 and 2000 year-classes were evident near 17 mm, 14 mm and between 8 and 10 mm repectively. Largest males (> 19 mm) and smallest females (< 22 mm) are thought to belong to the 1996 year-class. The 2001 distribution of females appears broader than 2000 distribution for females. This suggests that the 2001 female distribution is probably less reliant upon one cohort of shrimp than the distribution from the previous year. It is probable that the spawning stock is composed of individuals from the weaker 1995 and 1996 year classes, as well as remnants from the stronger 1994 year class.

The time series provides a basis for comparison of relative year-class strength and illustrates the changes in stock composition over time. The 1995 year-class, at age 5 in 2000, age 4 in 1999, age 3 in 1998 and age 2 in 1997, was weaker than both the 1994 or 1993 year-classes at those ages. Further, the 1996 year-class, at age 5 in 2001, age 4 in 2000, age 3 in 1999 and age 2 in 1998, is the weakest observed. The 1997 year-class is stronger than the 1995 and 1996 and, at age 4 in 2001, also appears at least as strong as the 1993 and 1994 year-classes were in 1997 and 1998, respectively. The 1998 and 1999 year-classes appear to be similar to the 1997 year-class in strength. However, the 2000 year-class at age 1 appears weaker than most. Modal length at age varies between years reflecting different growth rates for the different cohorts.

## RESOURCE STATUS

Large vessel catch rates remained at the high levels attained since the mid 1990's. The research survey biomass/ abundance estimates showed an increase since 1997. The lower 95% confidence intervals for the biomass indices averaged 453,500 t (about 109 billion animals) during the 1996 - 2001 period. Research data showed that the 1996 year-class was weak compared to others produced during the 1990's. Although the 1995 year-class appeared weaker than most, female abundance remained high. However, the 1997 and 1998 year-classes are strong, the former being the most abundant year-class at age 4, within the time series. Residual 1994 year-class animals, as well as, the sex inversion of 1995 and 1996 year-classes maintained the spawning stock biomass (females). The fact that the 2001 female length frequency is broad relative to the 2000 length frequency suggests that the 2001 female distribution was less reliant upon any one year-class of animals. The positive effects of the stronger 1997 year-class upon spawning stock should be evident by 2003.

Commercial catch rates have remained stable while research indices of stock size have shown an increase since 1997. The resource in this area remains healthy with high biomass/ abundance of male and female components. Exploitation rates have remained low over the past 6 years and the fishery continues to cover a broad area. Therefore, fishery related impacts could not be detected from either the logbook, observer or the research data. The fact that catch per unit effort for the large vessels has been maintained at a high level, and the fishing fleets are able to take their quotas over broad geographic areas, throughout the year further suggest that the stock is healthy.

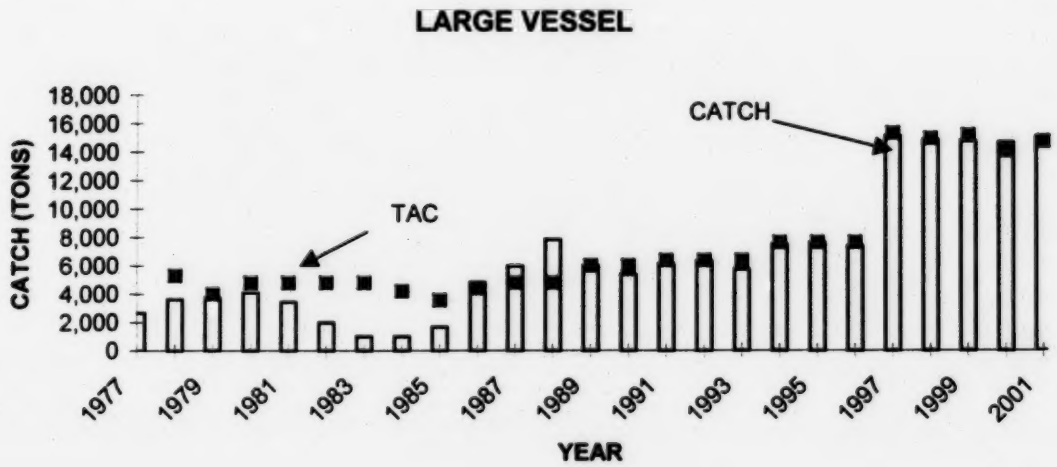
# ASSESSMENT OF SHRIMP IN HOPEDALE & CARTWRIGHT CHANNELS (SFA 5)

## FISHERY DATA

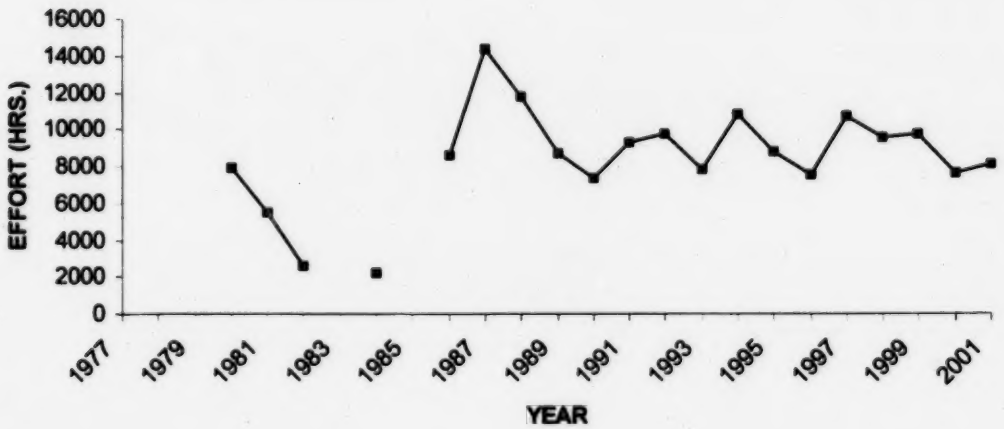
### Catch and effort

Shrimp catches in Hopedale and Cartwright Channels increased from about 2,700 t in 1977 to 4,100 t in 1980, declined to 1,000 t in 1983 and 1984, increased again to 7,800 t in 1988 and then stabilized at roughly 6,000 t during the 1989 - 1993 period. The TAC's for the 1994 - 1996 management plan, which combined the two channels as a single management area, were increased to 7,650 t annually and catches subsequently increased, averaging 7,500 t during that period. Annual TAC's for the 1997 - 1999 plan were increased 100% to 15,300 t and catches exceeded 15,000 t each year. The 15,300 t TAC (note that 1,530 t were set aside for the small vessel fleet) was maintained in the 2000 – 2002 plan and preliminary data indicate that approximately 15,100 t were caught

during 2001. The following chart indicates that transfers were added to the large vessel TAC's.



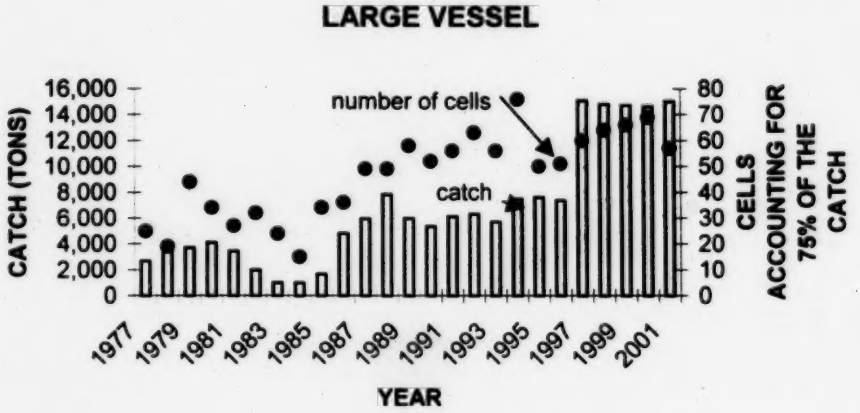

It should be noted that the TAC's and catches include transfers of quota from other sectors. Over the past ten years, fishing effort has remained relatively stable even though the TAC doubled between 1996 and 1997.




In the late 1970's and throughout the 1980's, the fishery concentrated in four main areas: northern, eastern and southern Hopedale Channel and Cartwright Channel. Fishing continued in the traditional areas during the 1990's, however, more effort was reported from the slopes of the shelf, north and east of

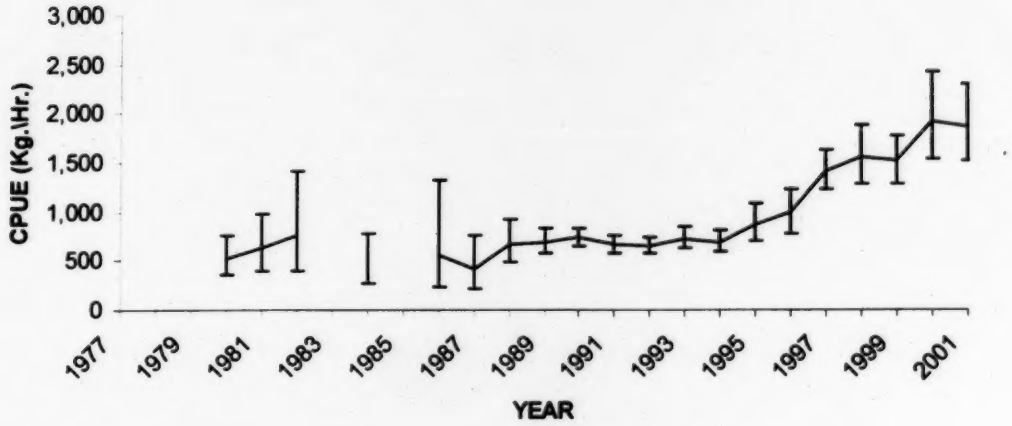
Cartwright Channel (Fig.10). From 1994 to 2001, substantial effort occurred on the eastern slope during winter and spring. Historically a summer - fall fishery for the large vessels, since 1995 it has become mainly a winter - spring operation (Fig. 11). An allocation (1530 t in 2001) has been available in recent years for small vessels but this fleet sector contributes only in a minor way to the fishery, and quota is often transferred to the large vessel fleet.

The plot of catch overlain upon the number of cells accounting for 75% of the catch indicates that despite a doubling of quota after 1997, the area fished remained similar to that of the previous decade.



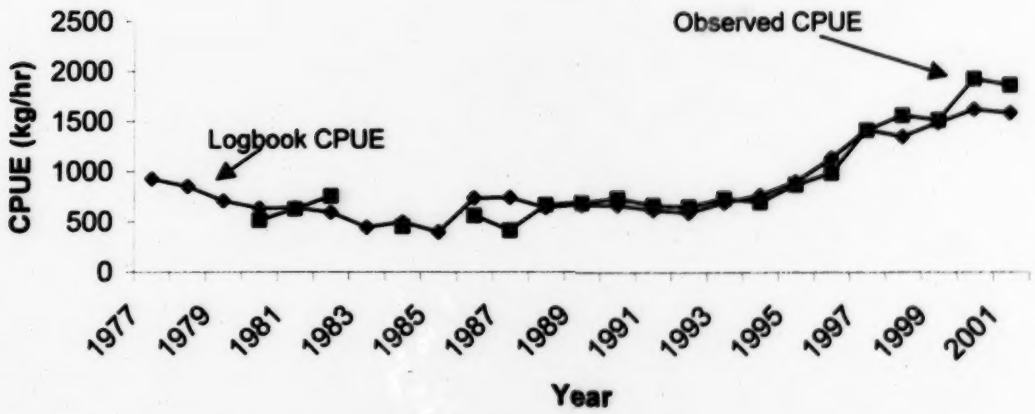

**Catch per unit effort (CPUE)**

Annual CPUE data (single trawl, no windows, observer data for vessels >500 t) were analyzed by multiple regression with effort weighting for year, month, vessel and area effects (Table 5). Lack of data during the early years and filtering resulted in missing points during 1977 – 1980, 1984 and 1986. The standardized catch rates were relatively stable between 1986 and the early 1990's. Standardized catch rates increased from 1993 through to 1998 after which they again stabilized. The 1998 – 2000 catch rates were statistically similar ($P>0.05$) to 2001 but all others were lower than 2001 ($P < 0.05$). Once again, maintaining a high cpue over a relatively broad area is an indication that the stock is healthy.




In general, the modeled logbook CPUE shows the same trend as the observer CPUE indicating that the observer dataset provides a fair representation of the fishery data.

**Comparison between large vessel SFA 5 (>500 t) CPUE models produced from Observer and Logbook datasets**

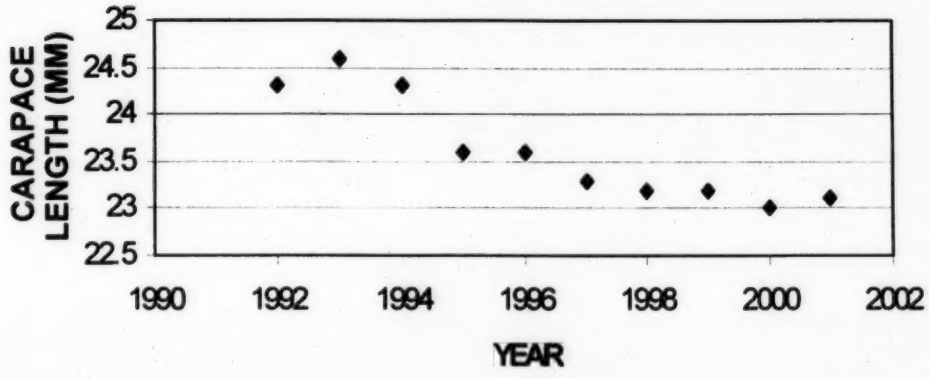



Historical fishery data for this management-assessment area are summarized in Table 6.

Size composition

Catch-at-length data from 1992 to 2001 (Fig. 12) showed a modal group of females about 23-24 mm CL occurring each year. While the catch rates for this component increased since the early 1990's, the mean size and median size at sex change declined slightly after 1994.

**TRENDS IN AVERAGE CARAPACE LENGTH AMONG FEMALES TAKEN IN THE LARGE VESSEL FISHERY**




Recruitment of males between approximately 16 and 22 mm was consistent from year to year and males contributed substantially to the catch in numbers up to 1999. The male component showed a decline since 1998, possibly a reflection of weaker 1995 and 1996 year-classes.

The recruitment, growth and maturation of the assumed 1991 year-class can be tracked from the 1995 - 1997 sampling data. It first appeared as male at 18 mm CL (age 4) in 1995, dominated the male component at roughly 20 mm (age 5) in 1996 and accounted for part of the females at 23 mm (age 6) in 1997. Similarly, the 1993 year-class can be tracked as males at 18 mm (age 4) in 1997, at about 20 mm (age 5) in 1998 and as females (age 6) in 1999. The 1994 year-class dominated the male component in 1999 and contributed substantially to the female group in 2000. The last panel indicates male modes at 16 – 18 and 20 mm probably reflecting the recruitment of the 1997 and weaker 1996 year-classes respectively. The 1997 year-class will be 5 years old during 2002 at which time many of the males should change sex to become females.

## RESEARCH SURVEY DATA

### Stock size

Long term research plans call for the northern part of SFA 5 (Hopedale Channel – Div. 2H) to be surveyed every two years. This area was surveyed during 2001 (Figs. 13 & 14). Therefore, 1996 – 2001 biomass/ abundance estimates for Hopedale Channel and Cartwright Channel were analysed to compare trends. If trends are similar, it may be possible to model biomass/ abundance estimates for Hopedale Channel when there is no survey in that area.

**Northern shrimp stock size estimates in Cartwright Channel (SFA 5) from offshore fall research trawl surveys, 1996 - 2001.**

| | Biomass (tons) | | | Abundance (numbers x $10^{-6}$) | | |
|---|---|---|---|---|---|---|
| Year | Lower C.I. | Estimate | Upper C.I. | Lower C.I. | Estimate | Upper C.I. |
| 1996 | 26,300 | 75,250 | 189,000 | 5,460 | 20,300 | 57,100 |
| 1997 | 34,500 | 49,100 | 67,000 | 7,140 | 10,400 | 15,100 |
| 1998 | 31,800 | 43,300 | 55,900 | 6,280 | 8,640 | 11,200 |
| 1999 | 41,300 | 56,600 | 73,800 | 8,240 | 11,000 | 14,200 |
| 2000 | 44,000 | 71,700 | 114,000 | 10,500 | 16,700 | 25,600 |
| 2001 | 69,200 | 88,200 | 115,000 | 16,900 | 21,500 | 27,600 |

[1] **Area compared each year = 25204.6 sq. km.**

**Northern shrimp stock size estimates in Hopedale Channel (SFA 5) [2] from fall research trawl surveys - offshore, 1996 - 2001.**

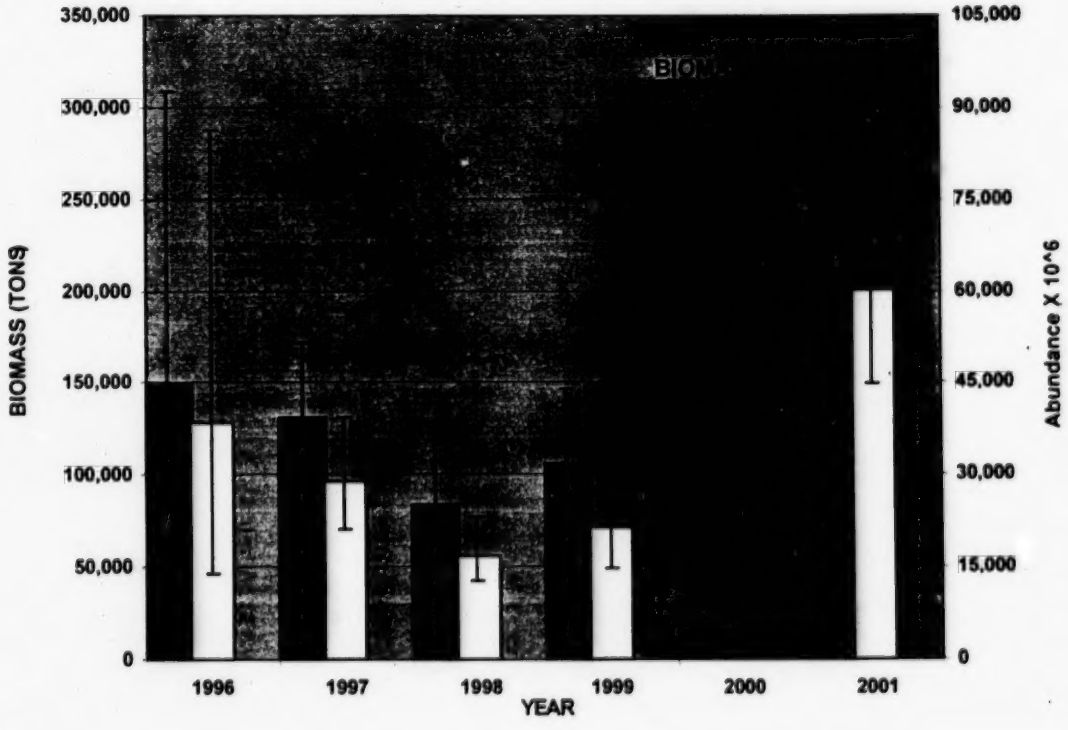
| | Biomass (tons) | | | Abundance (numbers x $10^{-6}$) | | |
|---|---|---|---|---|---|---|
| Year | Lower C.I. | Estimate | Upper C.I. | Lower C.I. | Estimate | Upper C.I. |
| 1996 | 30,800 | 64,600 | 118,000 | 6,690 | 14,350 | 29,300 |
| 1997 | 52,300 | 81,800 | 114,000 | 11,700 | 18,050 | 25,900 |
| 1998 | 25,400 | 41,700 | 67,500 | 5,220 | 8,600 | 14,000 |
| 1999 | 27,100 | 50,800 | 86,000 | 5,440 | 10,300 | 17,600 |
| 2000 | | | | | | |
| 2001 | 103,000 | 149,500 | 209,000 | 25,000 | 37,300 | 52,500 |

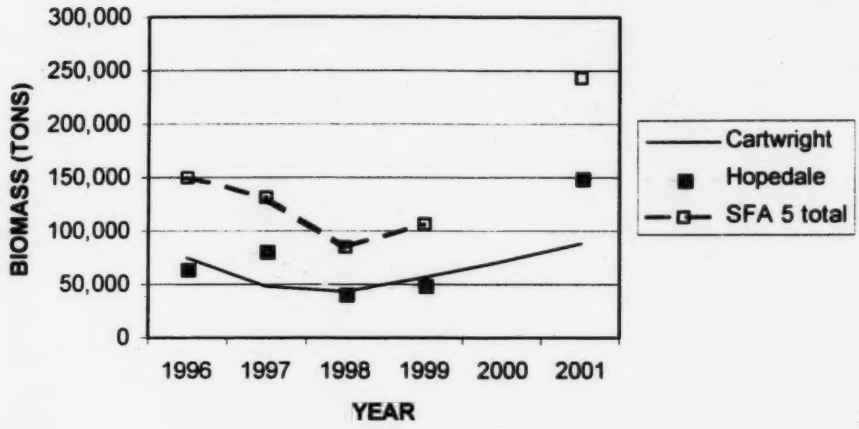
[2] **Area compared each year = 34,282.2 sq. km.**

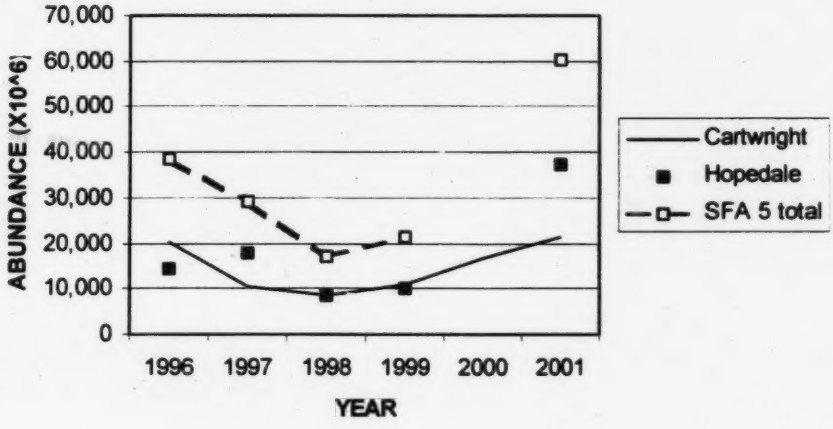
**Northern shrimp stock size estimates in Hopedale+Cartwright (SFA 5) [3] from fall research trawl surveys - offshore, 1996 - 2001.**

| | Biomass (tons) | | | Abundance (numbers x $10^{-6}$) | | | No. |
|---|---|---|---|---|---|---|---|
| | Lower C.I. | Estimate | Upper C.I. | Lower C.I. | Estimate | Upper C.I. | Sets |
| 1996 | 64,340 | 149,850 | 308,300 | 13,740 | 38,445 | 86,150 | 111 |
| 1997 | 96,710 | 131,600 | 172,000 | 21,150 | 29,055 | 39,460 | 112 |
| 1998 | 63,210 | 84,240 | 113,000 | 12,640 | 16,920 | 23,040 | 119 |
| 1999 | 77,600 | 106,500 | 147,000 | 14,800 | 21,320 | 29,390 | 117 |
| 2000 | | | | | | | |
| 2001 | 183,100 | 242,700 | 309,000 | 44,880 | 60,110 | 75,980 | 90 |

[3] **Area compared each year = 60,578.6 sq. km.**



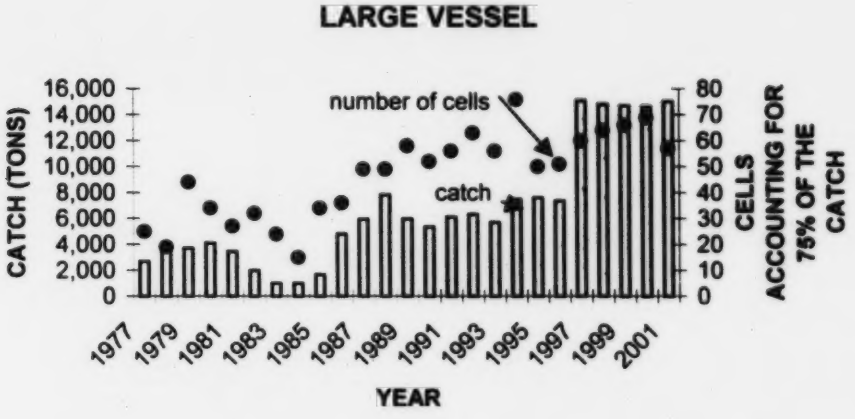



Between 1996 and 1997, stock indices increased for Hopedale Channel but decreased for Cartwright. Confidence intervals for the 1996 survey estimates were wide due to two anomalously high catches (Fig. 13 & 14). Therefore, usefulness of the results by area or for the total was limited. In 1997, the Hopedale Channel results were overestimated because shallow areas (< 200 m) of the Nain Bank were not sampled and the method interpolated shrimp catches from deeper water over a large area where densities are known to be lower. The 1998, 1999 and 2001 survey indices showed similar trends. This is encouraging; however, it is not yet possible to assume that trends observed within the Cartwright Channel reflect conditions throughout the whole management area.

A comparison between Figures 7-8 and 13-14 illustrates that the distribution of animals is more widespread and evenly dispersed within SFA 6 than SFA 5. The fact that shrimp are highly concentrated in two main channels and along the shelf edge within SFA 5 helps account for the broad confidence limits around the point

estimates. The fishery is taking place in areas of high research catches (Figures 10-11 and 13-14). The areal index used in tracking the fishery (number of cells accounting for 75% of the catch) is lower within SFA 5 than in SFA 6, but this is probably more a function of habitat than an indicator of relative stock health. There is more suitable habitat within SFA 6 than there is in SFA 5 therefore the animals and hence the fishery is more dispersed within SFA 6.




Exploitation rates using the lower 95% confidence limit of the total biomass estimate, the spawning stock biomass and the fishable biomass are as follows:

| Year | Catch (large + small vessel) (t) | Lower C.I. of Total Biomass (t) | SSB (t) | Fishable Biomass (t) |
|---|---|---|---|---|
| 1996 | | 64,340 | 33,875 | 83,744 |
| 1997 | 15,103 | 96,710 | 40,510 | 107,502 |
| 1998 | 15,170 | 63,210 | 37,550 | 76,654 |
| 1999 | 14,971 | 77,600 | 49,915 | 97,144 |
| 2000 | 15,136 | | | |
| | | | | |

| Year | Catch Lower C.I. of Total Biomass | Catch SSB | Catch Fishable Biomass |
|---|---|---|---|
| 1997 | 0.23 | 0.45 | 0.18 |
| 1998 | 0.16 | 0.37 | 0.14 |
| 1999 | 0.24 | 0.40 | 0.20 |
| 2000 | 0.19 | 0.30 | 0.16 |

Each of these methods indicate that even though catches have been stable over the period 1997 – 2000, exploitation may vary due to annual variation in shrimp

biomass. Since the catchability of the research trawl is thought to be less than 1, it is likely that the true exploitation rates are lower than indicated above. These exploitation rates are higher than those in SFA 6, however, the biomass/ abundance indices have shown increases in the presence of the fishery, therefore, one can not conclude that the present exploitation levels are too high. Under the present circumstances we do not know what the maximum safe exploitation level is.

Biomass/ abundance of males has varied between 46,000 t (12 billion animals) and 148, 000 t (48 billion animals) without trend since 1996. The high 1996

**Stock size estimates for male and female shrimp in Hopedale+ Cartwright (SFA 5) from fall research trawl surveys - offshore, 1996 - 2001.**

| | Biomass (tons) | | | Abundance (numbers x $10^{-6}$) | | |
|---|---|---|---|---|---|---|
| | Males | Females | Total | Males | Females | Total |
| 1996 | 116,850 | 33,875 | 150,725 | 34,444 | 4,037 | 38,480 |
| 1997 | 89,905 | 40,510 | 130,415 | 23,925 | 4,950 | 28,875 |
| 1998 | 46,490 | 37,550 | 84,040 | 12,250 | 4,607 | 16,857 |
| 1999 | 55,825 | 49,915 | 105,740 | 14,875 | 6,203 | 21,078 |
| 2000 | | | | | | |
| 2001 | 148,350 | 94,270 | 242,620 | 47,860 | 12,450 | 60,310 |

estimates may be partially explained by a few anomalously high sets. As indicated above, the 1997 estimates may also have been high because the estimation technique estimated biomass/ abundance for Nain Bank even though the survey did not extend into waters <200 m.

The 2001 estimates may not be comparable with estimates from other years because:

1) the survey in SFA 5 was in December rather than October;
2) the survey made use of the CCG Alfred Needler rather than the CCG Teleost and;
3) there were approximately 10 planned sets in the southeastern portion of 2H that were not surveyed.

**Stock Composition**

A comparison between Figures 9 and 15 indicates that the relative strength of year classes is maintained, but becomes less pronounced, and the recruitment signal from the ages 1 & 2 shrimp becomes less obvious as one moves north. The 1997 year-class animals were 8-10 mm in 1998, 13-15 mm in 1999 and 18 mm in 2001 (Fig. 15). Similarly, the 1998 year-class animals were present as 9 – 10 mm animals in 1999, and 15 – 17 mm animals in 2001. These two age classes appear at least as strong as the 1993 year class, at the same ages. The 1995 year-class appeared average in strength throughout the time series, while the 1996 year-class was relatively weak. The 1995 year-class was mostly females during 2001. Part of the 1997 year-class will be female during 2002 and

most of them will be female by 2003. The 2001 distribution of females appears to be the broadest in the time series, indicating that it is also less reliant on any one year-class than the 1999 females (Fig. 15).

## RESOURCE STATUS

The issues of timing of the survey, change in ship, missing sets in the southeast force us to be cautious about the interpretation of the research survey results in 2001.

Large vessel catch rates have shown an increase since the mid 1990's. The research survey biomass/ abundance estimates showed an increase since 1998. The lower 95% confidence intervals for the biomass indices averaged 108,000 t (about 24 billion animals) during the 1998 - 2001 period. Research data showed that the 1996 year-class was weak compared to others produced during the 1990's. The 1995 year-class appeared average and female abundance remained high. The 1997 and 1998 year-classes appear strong and at least comparable with the 1994 year-class at age 4. Residual 1994 class animals, as well as, the sex inversion of 1995 and 1996 year-classes maintained the spawning stock biomass (females). The inversion of several year-classes is suggested by the fact that the 2001 female length frequency is broad relative to the 1999 length frequency. The positive effects of the stronger 1997 and 1998 year-classes on the spawning stock should be evident by 2003 and 2004.

Commercial catch rates have remained stable since 1997 while research indices of stock size have shown an increase over the same period. The resource in this area remains healthy with high biomass/ abundance of male and female components. Exploitation has fluctuated over the past 5 years and the fishery continues to cover a broad area. Therefore, fishery related impacts could not be detected from either the logbook, observer or the research data. The fact that CPUE has been increasing in recent years and the fishing fleets are able to take their quotas over broad geographic areas suggests that the stock is healthy.

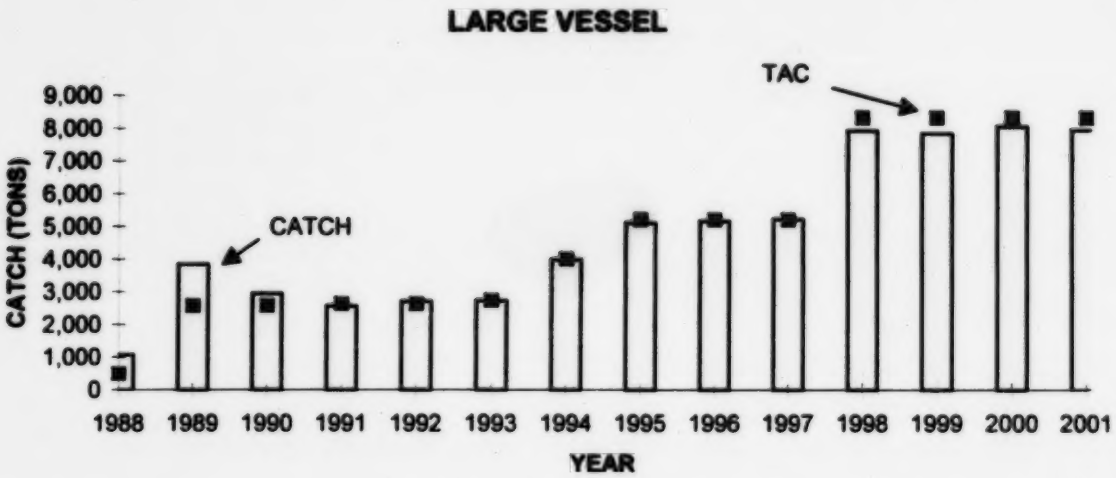
# ASSESSMENT OF SHRIMP IN NAFO DIVISION 2G (SFA 4)

## FISHERY DATA

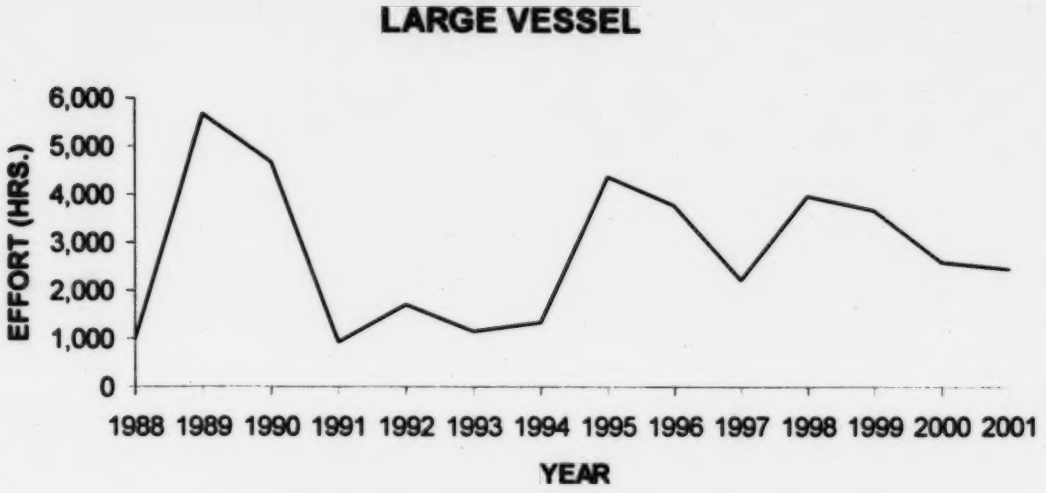
### Catch and effort

Shrimp catches increased from 1,083 t in 1988 to 3,842 t in 1989 and remained within the 2,500 – 3,000 t range up to and including 1993. The 1994 catch increased to 3,982 t with an increase in TAC to 4,000 t in the first year of the 1994 - 1996 Management Plan. A second increase to 5,200 t for 1995 and 1996 resulted in catches of about 5,100 t in both years. The TAC of 5,200 t was maintained for 1997 and catch was estimated at 5,216 t.

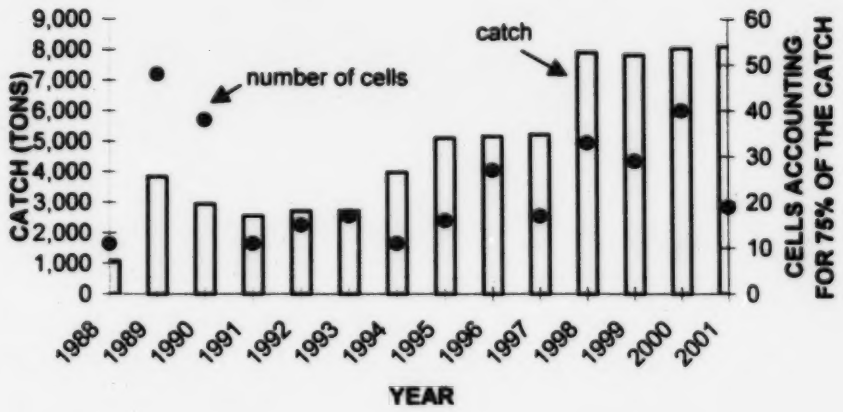
The interim review of stock status in the winter of 1998 indicated that an increase in TAC could be considered. Lacking the basis on which to advise an appropriate level of TAC, an increase of 60% (3,120 t) to 8,320 t was chosen in the management process. Furthermore, 70% of the increase (2,184 t) was applied to the area south of $60^0$ N where very little fishing had occurred since 1990. Catches from 1998 to 2001 were estimated at approximately 8,000 t each year. Please note that the following chart of large vessel TAC's and catches includes quota transfers from other sectors.




Effort increased substantially from 1988 to 1989, then decreased until 1991 after which it remained at a relatively stable low level until 1994. It increased during 1995 and varied at a higher level, thereafter. The fishery from 1988 to 1990 occurred throughout the Division, which, during that period, was split into two management zones, north and south of $60^0$ N. The 1991 - 1993 Management Plan combined the two zones and, up to 1997, effort concentrated primarily in the north (Fig. 16). From 1998 to 2001, more effort was deployed south of $60^0$ N because of the separate quota for that area. By-catches of *P. montagui* were reported at some northwestern locations during the 1995 - 2001 period. Fishing occurred in January – February 2001, and then resumed in July and continued until the end of the year (Fig. 17).



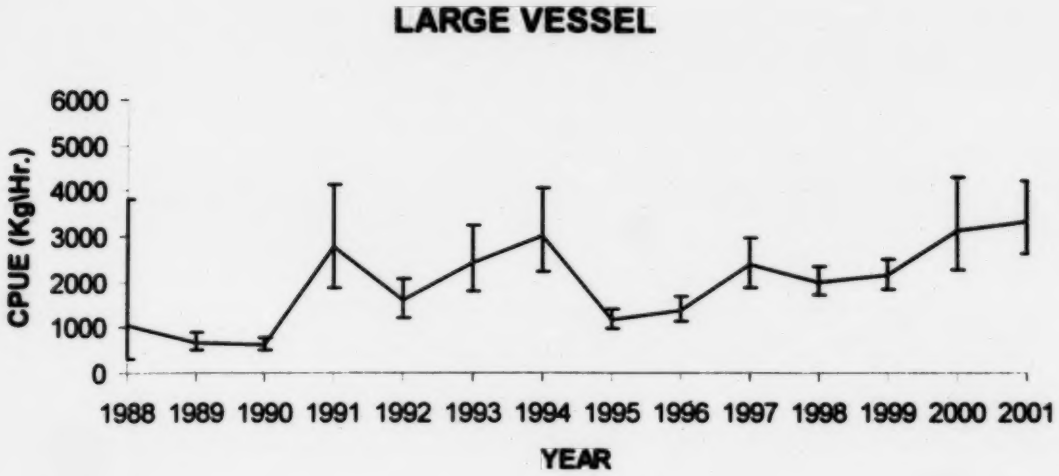

The overlay of number of cells accounting for 75% of the catch upon the actual catches reflects these changes in Management Plan. The number of cells generally increased during periods in which there was a separate quota for the southern portion of SFA 4. However, it decreased between 2000 and 2001. The 2001 value is within the 1995 – 2000 range of values. This is only one point in the chart, therefore, it is impossible to interpret the significance of the drop.



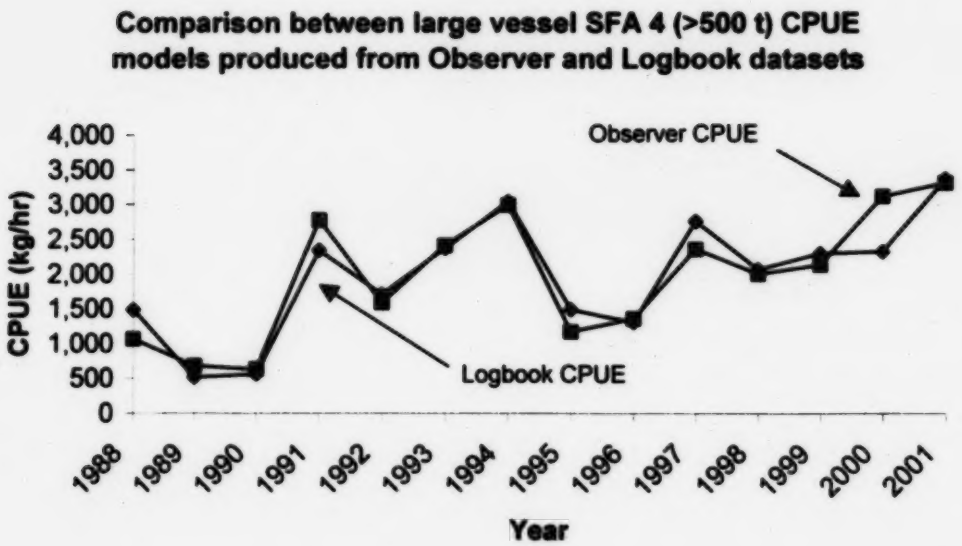

**Catch per unit effort (CPUE)**

The CPUE data were analyzed by multiple regression, weighted by effort, for year, month and vessel effects. The model showed that the annual, standardized catch rates for 1988, 1991, 1993, 1994 and 2000 were similar (P >

0.05) to the 2001 estimate. Since 1995, catch rates have increased (Tables 7 & 8).




The observer based model is similar to the logbook model.

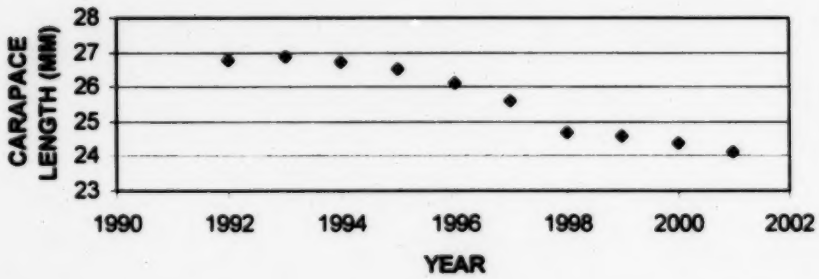


Size composition

Catch-at-length data for the 1992 - 2001 period showed variable size distributions among years (Fig. 18). Since 1992, the mean length of females and median size at sex inversion has declined. However, decreases since 1998 are thought to reflect increased fishing in southern 2G where growth rates and maturity schedules resemble those seen in the Hopedale + Cartwright area.

Given the recent high and stable catch rates of primarily female shrimp in this area, it appears that a healthy spawning biomass is being maintained. The narrow distribution of female sizes in 2000 and 2001 compared to previous years suggests fewer older females in the catches.

**TRENDS IN AVERAGE CARAPACE LENGTH AMONG FEMALES TAKEN IN THE LARGE VESSEL FISHERY**




## RESEARCH SURVEY DATA

No research survey was conducted in this area in 2001. Therefore, no direct comparison with previous stock size estimates and stock composition is possible.

## RESOURCE STATUS

The spawning stock appears healthy, as evidenced in continued high catch rates of large female shrimp and stability in catch rates. However, current status and prospects are unknown because the lack of a survey precludes evaluation of stock size, level of exploitation and future recruitment.

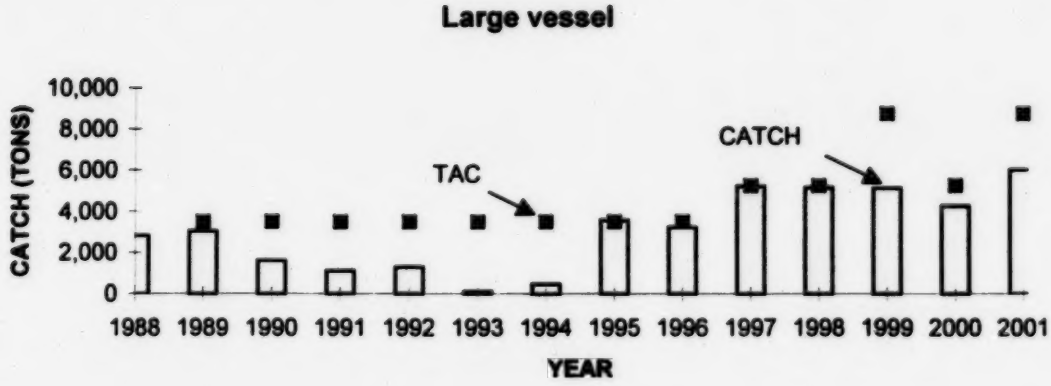
## ASSESSMENT OF SHRIMP IN NAFO DIVISION 0B (SFA 2)

### FISHERY DATA

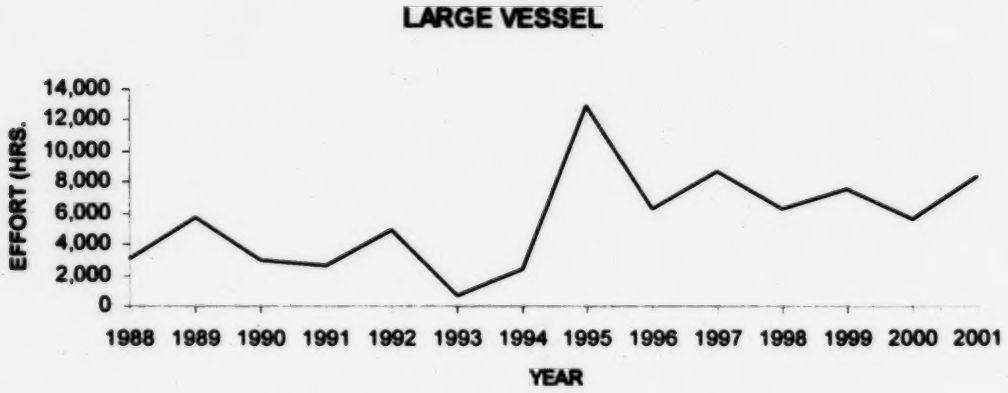
#### Catch and effort

Catches of *Pandalus borealis* in Div. 0B increased from about 2,800 t in 1988 to 3,000 t in 1989 but subsequently declined to 100 t in 1993. The 1994 catch was less than 500 t; however, catches increased substantially to about 3,600 and 3,200 t in 1995 and 1996, respectively, and to more than 5,000 t each year from 1997 to 2000. Preliminary estimates indicate that approximately 6,000 t were caught during 2001.

Recent catches for the species have been estimated, in part, from the mixed fishery data for *P. borealis montagui* in the area east of Resolution Island but their accuracy is questionable. *Pandalus borealis* taken in the immediately adjacent areas of SFA's 3 and 4 were included in the catches reported for SFA 2. TAC's remained at 3,500 t from 1989 to 1996 but were increased experimentally to 5,250 t for 1997 and 1998. In 1999, an additional 3,500 t were provided for the area north of $63^0$ N as an incentive for the offshore fleet to return to grounds not fished extensively since 1995. However, just over 100 t were taken within this area in 1999. In 2000, the additional 3,500 t was not included in the quota report, and accordingly the catch was not counted against the TAC for the south (5,250 t). In 2001, the additional 3,500 t was included in the quota report as an exploratory quota east of 63°W. The preliminary data suggest that approximately 5,400 t were taken in the south. Approximately 640 t were taken in the exploratory area.

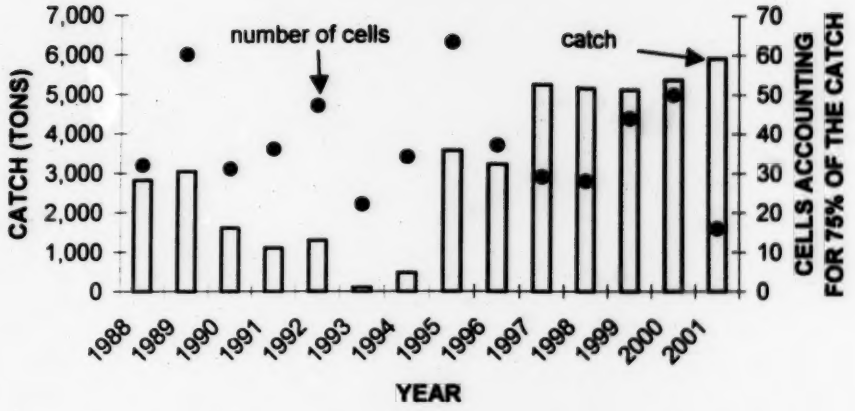



Fishing effort doubled from 1988 to 1989, decreased in 1990 and remained near the 1990 level for the next two years. Effort increased from a low in 1993 to 1995 and has since remained relatively stable.




In the late 1980's, fishing effort was primarily concentrated between $64^0$ and $65^0$ N, whereas, during the 1990 - 1994 period, proportionately more was distributed south of $64^0$ N. The areas fished extensively in the southwest from 1995 to 2000 reflect the targeting of *Pandalus borealis* and *P. montagui* concentrations east of Resolution Island. Most effort since 1996 occurred south of $63^0$ N (Fig. 19). In 2001, fishing began during the summer and continued until at least October (Fig. 20).

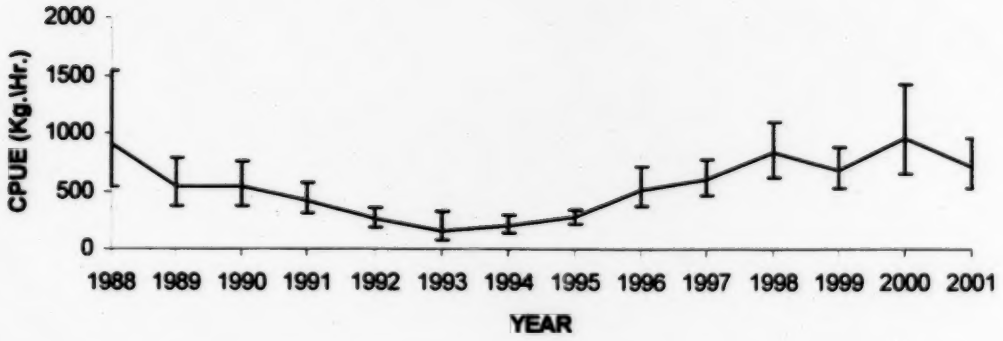
The amount of area accounted for in 75% of the catch is at the lowest level in 13 years. The index of cells provides confounded results in 0B because of the data reporting problems (both in terms of reporting catches against SFA quota and the mixture of *Pandalus borealis* with *P. montagui*) and the frequent changes in quota. The distribution of shrimp appears to be patchy and as new patches of shrimp were discovered, the fishery changed both in area accounted for in catching allocations and locations fished.




**Catch per unit effort (CPUE)**

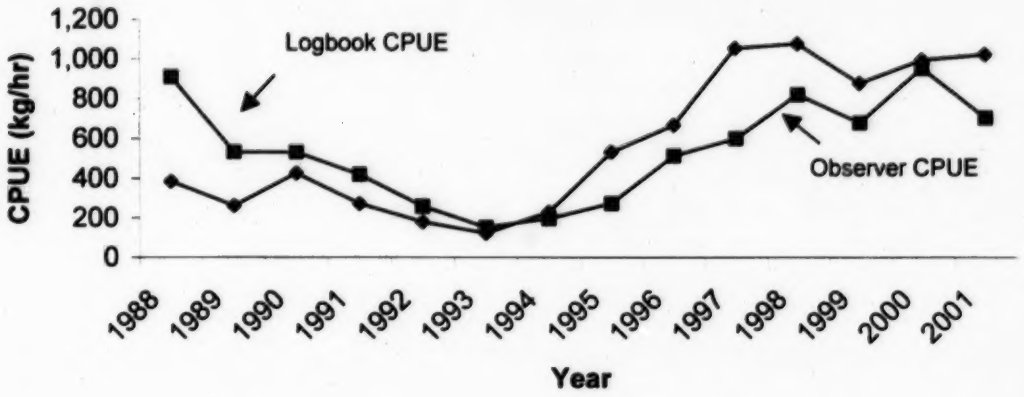
The standardized annual CPUE showed an overall decline from 1988 to 1993. Catch rates increased sharply from 1993 to 1996 after which they remained stable. The model was standardized for year, month and vessel effects with effort weighting showed that the 1988 - 1990 and 1996 - 2000 catch rates were similar to the 2001 estimate ($P > 0.05$) while all other estimates were significantly lower ($P < 0.05$) than the 2001 estimate (Tables 9 & 10). The pronounced increase in CPUE after 1993 is associated with the shift of fishing effort to the southwest.

**LARGE VESSELS**




The CPUE model derived using observer data was similar to the model using logbook data.

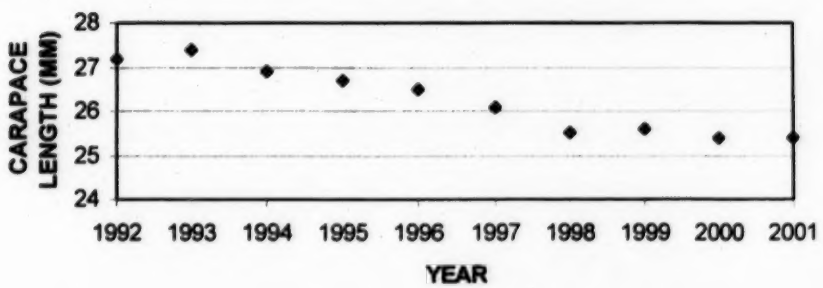
**Comparison between SFA 2 large vessel (>500 t) Observer and Logbook CPUE models**




**Size composition**

Catches in most years were composed primarily of large, female shrimp (Fig. 21) with a modal length of about 27 mm CL. However, the mean size of females and the median size at sex change declined after 1996. The occurrence of males <22 mm in the catches, as well as, the overall catch rates of male and female components, increased with the southward shift in fishing effort. As seen in the southern areas, the narrow distribution of female sizes in 2000 compared to previous years suggests fewer older females in the catches.

**TRENDS IN AVERAGE CARAPACE LENGTH AMONG FEMALES TAKEN IN THE LARGE VESSEL FISHERY**



## RESOURCE STATUS

Although shrimp concentrations in the northeast are elusive, as evidenced by the low catches in recent years, from the area north of $63^0$ N, those adjacent to eastern Resolution Island have persisted since first fished in 1995. However, the population structure is uncertain throughout Div. 0B and distribution is unknown for much of the year. Therefore, the current status of this resource remains uncertain.

After 1994, the fishery shifted to the southwest, east of Resolution Island, therefore, the CPUE and sampling data are not considered to be representative of stock conditions. The new index of area fished is also confounded by the elusive nature of the stocks. Patches of shrimp may be present, however, the fishing crews may not always find them. If a crew can fill their quota in a patch, there may not be an incentive to search for other patches. The mixed fishery for *Pandalus borealis/ montagui* confounds the assessment and the lack of knowledge on the distribution and abundance/ biomass of both species will persist in the absence of a time series of research trawl surveys. Prospects are unknown.

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Table 1. Multiplicative, year month vessel area model for CPUE in Hawke Channel + 3K, 1988 - 2001, weighted by effort. (large vessel (>500 t), single trawl, no windows, observer data)

General Linear Models Procedure

Class Level Information

| Class | Levels | Values |
|---|---|---|
| YEAR | 14 | 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 |
| MONTH | 5 | 2 3 4 5 99 |
| VESSEL | 13 | |
| AREA | 7 | 67 68 69 90 91 92 999 |

Number of observations 851

Dependent Variable: LNCPUE
Weight: WFACTOR

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 35 | 27934.51310 | 798.12895 | 65.45 | <.0001 |
| Error | 815 | 9937.74542 | 12.19355 | | |
| Corrected Total | 850 | 37872.25853 | | | |

| R-Square | Coeff Var | Root MSE | LNCPUE Mean |
|---|---|---|---|
| 0.737598 | 49.62147 | 3.491927 | 7.037129 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 13 | 24230.11328 | 1863.85487 | 152.86 | <.0001 |
| MONTH | 4 | 287.63570 | 71.90892 | 5.90 | 0.0001 |
| VESSEL | 12 | 1877.08617 | 156.42385 | 12.83 | <.0001 |
| AREA | 6 | 1539.67796 | 256.61299 | 21.04 | <.0001 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 13 | 4016.208063 | 308.939082 | 25.34 | <.0001 |
| MONTH | 4 | 793.568201 | 198.392050 | 16.27 | <.0001 |
| VESSEL | 12 | 1936.801834 | 161.400153 | 13.24 | <.0001 |
| AREA | 6 | 1539.677962 | 256.612994 | 21.04 | <.0001 |

| Parameter | | Estimate | | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|
| Intercept | | 7.294282123 | B | 0.09932919 | 73.44 | <.0001 |
| YEAR | 1988 | -1.025370911 | B | 0.16399065 | -6.25 | <.0001 |
| YEAR | 1989 | -1.270326219 | B | 0.12100489 | -10.50 | <.0001 |
| YEAR | 1990 | -1.304130296 | B | 0.11998049 | -10.87 | <.0001 |
| YEAR | 1991 | -0.779258550 | B | 0.11316452 | -6.89 | <.0001 |
| YEAR | 1992 | -0.581109970 | B | 0.11335696 | -5.13 | <.0001 |
| YEAR | 1993 | -0.421176813 | B | 0.11112811 | -3.79 | 0.0002 |
| YEAR | 1994 | -0.291693908 | B | 0.10108555 | -2.89 | 0.0040 |
| YEAR | 1995 | -0.104253367 | B | 0.10312615 | -1.01 | 0.3123 |
| YEAR | 1996 | -0.052126517 | B | 0.10878001 | -0.48 | 0.6319 |
| YEAR | 1997 | 0.227579600 | B | 0.11200516 | 2.03 | 0.0425 |
| YEAR | 1998 | -0.048807756 | B | 0.10142449 | -0.48 | 0.6305 |
| YEAR | 1999 | 0.018138458 | B | 0.10017997 | 0.18 | 0.8564 |
| YEAR | 2000 | 0.234995728 | B | 0.12068053 | 1.95 | 0.0518 |
| YEAR | 2001 | 0.000000000 | B | . | . | . |

TABLE 2. NORTHERN SHRIMP LARGE VESSEL (>500 t) SHRIMP FISHERY DATA FOR HAWKE CHANNEL + 3K (SFA 6), 1977 - 2001.

| YEAR | [1] TAC (t) | [2] FLEET CATCH (t) | [3] PERCENT CATCH OBSERVED | UNSTANDARDIZED CPUE (KG/HR) | CPUE INDEX | [4] EFFORT (HR) | STANDARDIZED RELATIVE CPUE | STANDARDIZED MODELLED CPUE | EFFORT (HRS) |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | | 1 | | | | | | | |
| 1978 | 1,300 | | | | | | | | |
| 1979 | 2,250 | 5 | | | | | | | |
| 1980 | 1,350 | | | | | | | | |
| 1981 | 1,350 | 135 | | | | | | | |
| 1982 | 1,350 | 1 | | | | | | | |
| 1983 | 1,350 | | | | | | | | |
| 1984 | 1,350 | | | | | | | | |
| 1985 | 1,350 | | | | | | | | |
| 1986 | 2,050 | | | | | | | | |
| 1987 | 3,000 | 1,845 | | | | | | | |
| 1988 | 3,000 | 7,849 | 8 | 500 | 0.21 | 15,695 | 0.36 | 517 | 15,193 |
| 1989 | 5,600 | 6,662 | 19 | 373 | 0.16 | 17,846 | 0.28 | 404 | 16,475 |
| 1990 | 5,600 | 5,598 | 35 | 525 | 0.22 | 10,667 | 0.27 | 391 | 14,320 |
| 1991 | 4,301 | 5,500 | 57 | 619 | 0.26 | 8,883 | 0.46 | 661 | 8,324 |
| 1992 | 7,565 | 6,609 | 50 | 865 | 0.37 | 7,644 | 0.56 | 806 | 8,204 |
| 1993 | 9,180 | 8,035 | 62 | 1,003 | 0.43 | 8,008 | 0.66 | 945 | 8,500 |
| 1994 | 11,050 | 10,978 | 80 | 1,391 | 0.59 | 7,893 | 0.75 | 1,076 | 10,203 |
| 1995 | 11,050 | 10,914 | 92 | 1,771 | 0.75 | 6,161 | 0.90 | 1,298 | 8,410 |
| 1996 | 11,050 | 10,923 | 70 | 2,260 | 0.96 | 4,834 | 0.95 | 1,367 | 7,989 |
| 1997 | 15,335 | 14,954 | 48 | 1,978 | 0.84 | 7,648 | 1.26 | 1,808 | 8,269 |
| 1998 | 16,360 | 16,264 | 78 | 1,926 | 0.82 | 8,446 | 0.95 | 1,372 | 11,856 |
| 1999 | 17,603 | 17,587 | 74 | 1,986 | 0.84 | 8,855 | 1.02 | 1,467 | 11,991 |
| 2000 | 19,387 | 20,615 | 26 | 2,264 | 0.96 | 9,105 | 1.26 | 1,822 | 11,315 |
| 2001 | 20,103 | 19,894 | 18 | 2,356 | 1.00 | 8,329 | 1.00 | 1,440 | 13,812 |

[1]

HISTORICAL TAC'S APPLIED AS FOLLOWS:

1978 TO 1985 - INCLUDES 500 TON EXPLORATORY TAC FOR DIVISION 3K;

1986 TO 1988 - HAWKE CHANNEL, ST. ANTHONY BASIN;

1989 TO 1991 - HAWKE CHANNEL, ST. ANTHONY BASIN, EAST ST. ANTHONY AND FUNK ISLAND DEEP;

1992 - INCLUDES 1700 TONS EXPLORATORY;

1993 - INCLUDES 3400 TONS EXPLORATORY;

1994 - 1999 - ALL AREAS COMBINED.

TAC'S FROM 1987 TO 1990, INCLUSIVE, ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN.1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31).

TAC'S AFTER 1996 MAY INCLUDE TRANSFERS OF QUOTA FROM OTHER SECTORS.

[2]

CATCH (TONS) IN CALENDAR YEAR AS REPORTED IN LOG BOOKS FOR 1977, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1978 TO 1989 AND YEAR-END QUOTA REPORTS, THEREAFTER.

[3]

PERCENT CATCH OBSERED IN CALENDAR YEAR AS REPORTED IN STANDARDIZED OBSERVER DATA CPUE DATASET.

[4]

EFFORT CALCULATED FROM OFFSHORE VESSEL OBSERVER DATA, SINGLE TRAWL, NO WINDOWS.

Table 3. Multiplicative, year month vessel area model for CPUE in Hawke Channel + 3K, 1988 - 2001, weighted by effort. (small vessel (<500 t; LOA< 100'), single trawl, no windows, observer data)

General Linear Model Procedure
Class Level Information

| Class | Levels | Values |
|---|---|---|
| YEAR | 4 | 1998 1999 2000 2001 |
| MONTH | 8 | 4 5 6 7 8 9 10 11 |
| VESSEL | 35 | |
| AREA | 7 | 67 68 69 90 91 92 999 |

Number of observations 220

Dependent Variable: LNCPUE

Weight: WFACTOR

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 50 | 465.0106886 | 9.3002138 | 3.13 | <.0001 |
| Error | 169 | 502.7883808 | 2.9750792 | | |
| Corrected Total | 219 | 967.7990693 | | | |

| R-Square | Coeff Var | Root MSE | LNCPUE Mean |
|---|---|---|---|
| 0.480483 | 28.92762 | 1.724842 | 5.962613 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 78.5350077 | 26.1783359 | 8.80 | <.0001 |
| MONTH | 7 | 90.9781829 | 12.9968833 | 4.37 | 0.0002 |
| VESSEL | 34 | 229.0097903 | 6.7355821 | 2.26 | 0.0003 |
| AREA | 6 | 66.4877077 | 11.0812846 | 3.72 | 0.0017 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 73.9533878 | 24.6511293 | 8.29 | <.0001 |
| MONTH | 7 | 117.2607508 | 16.7515358 | 5.63 | <.0001 |
| VESSEL | 34 | 208.0236412 | 6.1183424 | 2.06 | 0.0015 |
| AREA | 6 | 66.4877077 | 11.0812846 | 3.72 | 0.0017 |

| Parameter | | Estimate | | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|
| Intercept | | 5.396806122 | B | 0.27951933 | 19.31 | <.0001 |
| YEAR | 1998 | 0.415821599 | B | 0.10323561 | 4.03 | <.0001 |
| YEAR | 1999 | 0.065390378 | B | 0.08680135 | 0.75 | 0.4523 |
| YEAR | 2000 | 0.144498589 | B | 0.06820436 | 2.12 | 0.0356 |
| YEAR | 2001 | 0.000000000 | B | . | . | . |

**TABLE 4. NORTHERN SHRIMP SMALL VESSEL (<500 t; loa<100') SHRIMP FISHERY DATA FOR HAWKE CHANNEL + 3K (SFA 6), 1997 - 2001.**

| YEAR | [1] TAC (t) | [2] FLEET CATCH (t) | [3] PERCENT CATCH OBSERVED | UNSTANDARDIZED CPUE (KG/HR) | CPUE INDEX | [4] EFFORT (HR) | STANDARDIZED RELATIVE CPUE | MODELLED CPUE | EFFORT (HRS) |
|---|---|---|---|---|---|---|---|---|---|
| 1997 | 7,765 | 6,064 | | | | | | | |
| 1998 | 29,840 | 30,073 | 2 | 415 | 1.07 | 72,402 | 1.52 | 516 | 58,308 |
| 1999 | 41,029 | 33,673 | 2 | 369 | 0.95 | 91,192 | 1.07 | 367 | 91,701 |
| 2000 | 41,521 | 42,651 | 3 | 429 | 1.10 | 99,351 | 1.16 | 391 | 109,126 |
| 2001 | 41,520 | 32,736 | 2 | 389 | 1.00 | 84,050 | 1.00 | 340 | 96,333 |

[1] TAC'S FOR SMALL VESSEL FISHERY BEGAN IN 1997 - ALL AREA COMBINED

[2] THE NORTHERN SHRIMP CATCHES FROM YEAR-END QUOTA REPORTS.

[3] PERCENT CATCH OBSERVED IN CALENDAR YEAR AS REPORTED IN STANDARDIZED OBSERVER DATA CPUE DATASET.

[4] EFFORT CALCULATED FROM OFFSHORE VESSEL OBSERVER DATA, SINGLE TRAWL, NO WINDOWS.

Table 5. Multiplicative, year month vessel area model for CPUE in Hopedale and Cartwright Channels, 1980 - 2001, weighted by effort. (large vessel (>500 t), single trawl, no windows, observer data)

The GLM Procedure
Class Level Information

| Class | Levels | Values |
|---|---|---|
| YEAR | 20 | 1980 1981 1982 1984 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 |
| MONTH | 12 | 1 2 3 4 5 6 8 9 10 11 12 99 |
| VESSEL | 19 | |
| AREA | 4 | 52 53 54 99 |

Number of observations 838

Dependent Variable: LNCPUE
Weight: WFACTOR

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 51 | 16705.54297 | 327.55967 | 25.79 | <.0001 |
| Error | 786 | 9983.03221 | 12.70106 | | |
| Corrected Total | 837 | 26688.57518 | | | |

| R-Square | Coeff Var | Root MSE | LNCPUE Mean |
|---|---|---|---|
| 0.625944 | 53.79325 | 3.563854 | 6.625097 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 19 | 12147.02669 | 639.31719 | 50.34 | <.0001 |
| MONTH | 11 | 2266.62109 | 206.05646 | 16.22 | <.0001 |
| VESSEL | 18 | 1925.64794 | 106.98044 | 8.42 | <.0001 |
| AREA | 3 | 366.24725 | 122.08242 | 9.61 | <.0001 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 19 | 3645.108552 | 191.847819 | 15.10 | <.0001 |
| MONTH | 11 | 1620.361029 | 147.305548 | 11.60 | <.0001 |
| VESSEL | 18 | 1956.247431 | 108.680413 | 8.56 | <.0001 |
| AREA | 3 | 366.247252 | 122.082417 | 9.61 | <.0001 |

| Parameter | | Estimate | | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|
| Intercept | | 7.589959441 | B | 0.12480678 | 60.81 | <.0001 |
| YEAR | 1980 | -1.280359482 | B | 0.23641482 | -5.42 | <.0001 |
| YEAR | 1981 | -1.088057836 | B | 0.27192067 | -4.00 | <.0001 |
| YEAR | 1982 | -0.901799449 | B | 0.35216126 | -2.56 | 0.0106 |
| YEAR | 1984 | -1.411744452 | B | 0.30974849 | -4.56 | <.0001 |
| YEAR | 1986 | -1.196316937 | B | 0.46824798 | -2.55 | 0.0108 |
| YEAR | 1987 | -1.503345119 | B | 0.32990263 | -4.56 | <.0001 |
| YEAR | 1988 | -1.027011859 | B | 0.19285316 | -5.33 | <.0001 |
| YEAR | 1989 | -0.990927201 | B | 0.12654804 | -7.83 | <.0001 |
| YEAR | 1990 | -0.926707744 | B | 0.11734098 | -7.90 | <.0001 |
| YEAR | 1991 | -1.031227791 | B | 0.11796843 | -8.74 | <.0001 |
| YEAR | 1992 | -1.052061645 | B | 0.11255197 | -9.35 | <.0001 |
| YEAR | 1993 | -0.933257098 | B | 0.11384468 | -8.20 | <.0001 |
| YEAR | 1994 | -0.983950775 | B | 0.11667436 | -8.43 | <.0001 |
| YEAR | 1995 | -0.760350589 | B | 0.14298728 | -5.32 | <.0001 |
| YEAR | 1996 | -0.634485350 | B | 0.14374850 | -4.41 | <.0001 |
| YEAR | 1997 | -0.275214956 | B | 0.11131286 | -2.47 | 0.0136 |
| YEAR | 1998 | -0.178616114 | B | 0.12949587 | -1.38 | 0.1682 |
| YEAR | 1999 | -0.208193427 | B | 0.11663063 | -1.79 | 0.0746 |
| YEAR | 2000 | 0.033118371 | B | 0.13779570 | 0.24 | 0.8101 |
| YEAR | 2001 | 0.000000000 | B | . | . | . |

**TABLE 6. NORTHERN SHRIMP LARGE VESSEL (>500 t) FISHERY DATA FOR HOPEDALE & CARTWRIGHT CHANNELS (SFA 6), 1977 - 2001.**

| YEAR | [1] TAC (t) | [2] FLEET CATCH (t) | [3] PERCENT CATCH OBSERVED | UNSTANDARDIZED CPUE (KG/HR) | CPUE INDEX | [4] EFFORT (HR) | STANDARDIZED RELATIVE CPUE | STANDARDIZED MODELLED CPUE | EFFORT (HRS) |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | | 2,686 | | | | | | | |
| 1978 | 5,300 | 3,630 | | | | | | | |
| 1979 | 4,000 | 3,727 | | 469 | 0.18 | 7,952 | | | |
| 1980 | 4,800 | 4,108 | 27 | 447 | 0.17 | 9,197 | 0.28 | 517 | 7,949 |
| 1981 | 4,800 | 3,449 | 26 | 388 | 0.15 | 8,879 | 0.34 | 626 | 5,507 |
| 1982 | 4,800 | 1,983 | 7 | 377 | 0.14 | 5,259 | 0.41 | 755 | 2,628 |
| 1983 | 4,800 | 1,000 | | | | | | | |
| 1984 | 4,200 | 1,002 | 15 | 342 | 0.13 | 2,933 | 0.24 | 453 | 2,211 |
| 1985 | 3,570 | 1,689 | | | | | | | |
| 1986 | 4,400 | 4,826 | 10 | 615 | 0.23 | 7,844 | 0.30 | 562 | 8,586 |
| 1987 | 4,800 | 5,956 | 2 | 809 | 0.31 | 7,365 | 0.22 | 413 | 14,405 |
| 1988 | 4,800 | 7,838 | 7 | 748 | 0.28 | 10,478 | 0.36 | 666 | 11,773 |
| 1989 | 6,000 | 5,985 | 23 | 611 | 0.23 | 9,794 | 0.37 | 690 | 8,671 |
| 1990 | 6,000 | 5,360 | 70 | 682 | 0.26 | 7,856 | 0.40 | 736 | 7,283 |
| 1991 | 6,375 | 6,118 | 60 | 565 | 0.21 | 10,821 | 0.36 | 663 | 9,228 |
| 1992 | 6,375 | 6,315 | 63 | 792 | 0.30 | 7,971 | 0.35 | 649 | 9,726 |
| 1993 | 6,375 | 5,719 | 79 | 714 | 0.27 | 8,006 | 0.39 | 731 | 7,821 |
| 1994 | 7,650 | 7,499 | 40 | 671 | 0.25 | 11,180 | 0.37 | 695 | 10,789 |
| 1995 | 7,650 | 7,616 | 16 | 924 | 0.35 | 8,241 | 0.47 | 869 | 8,762 |
| 1996 | 7,650 | 7,383 | 21 | 1,392 | 0.53 | 5,303 | 0.53 | 986 | 7,489 |
| 1997 | 15,300 | 15,103 | 51 | 1,424 | 0.54 | 10,603 | 0.76 | 1,412 | 10,696 |
| 1998 | 14,929 | 14,827 | 29 | 2,188 | 0.83 | 6,776 | 0.84 | 1,555 | 9,534 |
| 1999 | 15,136 | 14,720 | 47 | 2,024 | 0.77 | 7,273 | 0.81 | 1,510 | 9,749 |
| 2000 | 14,050 | 14,645 | 20 | 2,580 | 0.98 | 5,676 | 1.03 | 1,922 | 7,620 |
| 2001 | 14,694 | 15,036 | 24 | 2,634 | 1.00 | 5,709 | 1.00 | 1,859 | 8,087 |

[1] TAC'S FROM 1987 TO 1990, INCLUSIVE ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN. 1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31). TAC'S AFTER 1996 MAY INCLUDE TRANSFERS FROM OTHER SECTORS.

[2] CATCH (TONS) IN CALENDAR YEAR AS REPORTED IN LOG BOOKS FOR 1977, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1978 TO 1989 AND YEAR-END QUOTA REPORTS, THEREAFTER.

[3] PERCENT CATCH OBSERED IN CALENDAR YEAR AS REPORTED IN STANDARDIZED OBSERVER DATA CPUE DATASET.

[4] EFFORT CALCULATED FROM CATCH/CPUE. CPUE CALCULATED FROM OFFSHORE VESSEL OBSERVER DATA, OBSERVER DATA.

TABLE 7. Multiplicative, year month vessel area model for cpue in division 2G (SFA 4), 1988 - 2001, weighted by effort. (large vessel (>500 t), single trawl, no windows, observer data).

General Linear Model Procedure
Class Level Information

| Class | Levels | Values |
|---|---|---|
| YEAR | 14 | 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 |
| MONTH | 8 | 5 6 8 9 10 11 12 99 |
| VESSEL | 12 | |

Number of observations 326

Dependent Variable: LNCPUE
Weight: WFACTOR

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 31 | 6937.87006 | 223.80226 | 19.77 | <.0001 |
| Error | 294 | 3327.75914 | 11.31891 | | |
| Corrected Total | 325 | 10265.62920 | | | |

| R-Square | Coeff Var | Root MSE | LNCPUE Mean |
|---|---|---|---|
| 0.675835 | 46.22100 | 3.364359 | 7.278854 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 13 | 5926.714573 | 455.901121 | 40.28 | <.0001 |
| MONTH | 7 | 437.082847 | 62.440407 | 5.52 | <.0001 |
| VESSEL | 11 | 574.072642 | 52.188422 | 4.61 | <.0001 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 13 | 3177.655483 | 244.435037 | 21.60 | <.0001 |
| MONTH | 7 | 301.205733 | 43.029390 | 3.80 | 0.0006 |
| VESSEL | 11 | 574.072642 | 52.188422 | 4.61 | <.0001 |

| Parameter | | Estimate | | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|
| Intercept | | 8.120091637 | B | 0.16581437 | 48.97 | <.0001 |
| YEAR | 1988 | -1.134660081 | B | 0.66077757 | -1.72 | 0.0870 |
| YEAR | 1989 | -1.583563033 | B | 0.19608802 | -8.08 | <.0001 |
| YEAR | 1990 | -1.655600114 | B | 0.15523969 | -10.66 | <.0001 |
| YEAR | 1991 | -0.177589089 | B | 0.24175574 | -0.73 | 0.4632 |
| YEAR | 1992 | -0.736109601 | B | 0.18833794 | -3.91 | 0.0001 |
| YEAR | 1993 | -0.319578273 | B | 0.18757926 | -1.70 | 0.0895 |
| YEAR | 1994 | -0.101743865 | B | 0.19200534 | -0.53 | 0.5966 |
| YEAR | 1995 | -1.041034851 | B | 0.14062768 | -7.40 | <.0001 |
| YEAR | 1996 | -0.889353671 | B | 0.14518470 | -6.13 | <.0001 |
| YEAR | 1997 | -0.338900402 | B | 0.16936133 | -2.00 | 0.0463 |
| YEAR | 1998 | -0.503464753 | B | 0.13545909 | -3.72 | 0.0002 |
| YEAR | 1999 | -0.439465979 | B | 0.13780885 | -3.19 | 0.0016 |
| YEAR | 2000 | -0.062081333 | B | 0.19736761 | -0.31 | 0.7533 |
| YEAR | 2001 | 0.000000000 | B | . | . | . |

TABLE 8. NORTHERN SHRIMP LARGE VESSEL (>500 t) FISHERY DATA FOR DIV. 2G (SFA 4), 1979 - 2001.

| YEAR | TAC [1] (t) | FLEET CATCH [2] (t) | PERCENT CATCH [3] OBSERVED | UNSTANDARDIZED CPUE (KG/HR) | UNSTANDARDIZED CPUE INDEX | EFFORT [4] (HR) | STANDARDIZED RELATIVE CPUE | STANDARDIZED MODELLED CPUE | STANDARDIZED EFFORT (HRS) |
|---|---|---|---|---|---|---|---|---|---|
| 1979 | 500 | 3 | | | | | | | |
| 1980 | 500 | <1 | | | | | | | |
| 1981 | 500 | 2 | | | | | | | |
| 1982 | 500 | 5 | | | | | | | |
| 1983 | 500 | 30 | | | | | | | |
| 1986 | 500 | 2 | | | | | | | |
| 1987 | 500 | 7 | | | | | | | |
| 1988 | 500 | 1,083 | 13 | 4,852 | 1.46 | 223 | 0.32 | 1,065 | 1,017 |
| 1989 | 2580 | 3,842 | 14 | 753 | 0.23 | 5,102 | 0.21 | 680 | 5,649 |
| 1990 | 2580 | 2,945 | 57 | 629 | 0.19 | 4,682 | 0.19 | 633 | 4,654 |
| 1991 | 2635 | 2,561 | 50 | 3,372 | 1.01 | 759 | 0.84 | 2,774 | 923 |
| 1992 | 2635 | 2,706 | 53 | 1,874 | 0.56 | 1,444 | 0.48 | 1,587 | 1,705 |
| 1993 | 2735 | 2,723 | 65 | 3,150 | 0.95 | 864 | 0.73 | 2,407 | 1,131 |
| 1994 | 4000 | 3,982 | 47 | 3,588 | 1.08 | 1,110 | 0.90 | 2,993 | 1,330 |
| 1995 | 5200 | 5,104 | 57 | 1,140 | 0.34 | 4,477 | 0.35 | 1,170 | 4,362 |
| 1996 | 5200 | 5,160 | 45 | 1,393 | 0.42 | 3,704 | 0.41 | 1,362 | 3,790 |
| 1997 | 5200 | 5,216 | 53 | 2,888 | 0.87 | 1,806 | 0.71 | 2,361 | 2,209 |
| 1998 | 8320 | 7,918 | 71 | 2,194 | 0.66 | 3,609 | 0.60 | 2,003 | 3,953 |
| 1999 | 8320 | 7,836 | 72 | 2,375 | 0.71 | 3,299 | 0.64 | 2,135 | 3,670 |
| 2000 | 8320 | 8,048 | 17 | 2,670 | 0.80 | 3,045 | 0.94 | 3,114 | 2,584 |
| 2001 | 8320 | 7,947 | 37 | 3,323 | 1.00 | 2,441 | 1.00 | 3,314 | 2,398 |

[1] TAC'S FROM 1987 TO 1990, INCLUSIVE ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN.1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31). TAC'S AFTER 1995 INCLUDE TRANSFERS FROM OTHER SECTORS.

[2] CATCH (TONS) AS REPORTED IN: LOGBOOKS FOR 1979, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1980 TO 1989 AND FROM YEAR-END QUOTA REPORTS AND/OR LOGBOOKS, THEREAFTER.

[3] PERCENT CATCH OBSERED IN CALENDAR YEAR AS REPORTED IN STANDARDIZED OBSERVER DATA CPUE DATASET.

[4] EFFORT CALCULATED FROM OFFSHORE VESSEL OBSERVER DATA, SINGLE TRAWL, NO WINDOWS.

TABLE 9. Multiplicative, year month vessel area model for cpue in division 0B (SF2), 1988 - 2001, weighted by effort. (large vessel (>500 t), single trawl, no windows, observer data).

General Linear Model Procedure
Class Level Information

| Class | Levels | Values |
|---|---|---|
| YEAR | 14 | 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 |
| MONTH | 7 | 6 7 8 9 10 12 99 |
| VESSEL | 14 | |

Number of observations 314

Dependent Variable: LNCPUE
Weight: WFACTOR

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 32 | 12275.22897 | 383.60091 | 9.70 | <.0001 |
| Error | 281 | 11112.62139 | 39.54670 | | |
| Corrected Total | 313 | 23387.85036 | | | |

| R-Square | Coeff Var | Root MSE | LNCPUE Mean |
|---|---|---|---|
| 0.524855 | 100.7751 | 6.288616 | 6.240247 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 13 | 9772.368990 | 751.720692 | 19.01 | <.0001 |
| MONTH | 6 | 998.025402 | 166.337567 | 4.21 | 0.0005 |
| VESSEL | 13 | 1504.834583 | 115.756506 | 2.93 | 0.0005 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 13 | 5421.567665 | 417.043667 | 10.55 | <.0001 |
| MONTH | 6 | 994.397829 | 165.732972 | 4.19 | 0.0005 |
| VESSEL | 13 | 1504.834583 | 115.756506 | 2.93 | 0.0005 |

| Parameter | | Estimate | | Standard Error | t Value | Pr > \|t\| |
|---|---|---|---|---|---|---|
| Intercept | | 6.679434792 B | | 0.21074789 | 31.69 | <.0001 |
| YEAR | 1988 | 0.257213255 B | | 0.31085965 | 0.83 | 0.4087 |
| YEAR | 1989 | -0.280438548 B | | 0.26186534 | -1.07 | 0.2851 |
| YEAR | 1990 | -0.280385303 B | | 0.23441208 | -1.20 | 0.2327 |
| YEAR | 1991 | -0.520547477 B | | 0.22403572 | -2.32 | 0.0209 |
| YEAR | 1992 | -0.998389900 B | | 0.21732236 | -4.59 | <.0001 |
| YEAR | 1993 | -1.529218024 B | | 0.40710079 | -3.76 | 0.0002 |
| YEAR | 1994 | -1.275650292 B | | 0.22987882 | -5.55 | <.0001 |
| YEAR | 1995 | -0.944198044 B | | 0.17024019 | -5.55 | <.0001 |
| YEAR | 1996 | -0.317853071 B | | 0.21257758 | -1.50 | 0.1360 |
| YEAR | 1997 | -0.160528615 B | | 0.18620694 | -0.86 | 0.3894 |
| YEAR | 1998 | 0.154834691 B | | 0.19249566 | 0.80 | 0.4219 |
| YEAR | 1999 | -0.034849013 B | | 0.18568574 | -0.19 | 0.8513 |
| YEAR | 2000 | 0.303544658 B | | 0.23921479 | 1.27 | 0.2055 |
| YEAR | 2001 | 0.000000000 B | | . | . | . |

**TABLE 10. NORTHERN SHRIMP LARGE VESSEL (>500 t) FISHERY DATA FOR DIV. 0B (SFA 2), 1988 - 2001.**

| YEAR | TAC (t) | CATCH[2] (t) | PERCENT[3] CATCH OBSERVED | UNSTANDARDIZED CPUE (KG/HR) | CPUE INDEX | EFFORT[4] (HR) | STANDARDIZED RELATIVE CPUE | STANDARDIZED MODELLED CPUE | EFFORT (HRS) |
|---|---|---|---|---|---|---|---|---|---|
| 1988 | | 2,826 | 15 | 576 | 0.52 | 4,909 | 1.29 | 912 | 3,098 |
| 1989 | 3,500 | 3,039 | 20 | 317 | 0.29 | 9,585 | 0.76 | 533 | 5,704 |
| 1990 | 3,500 | 1,609 | 58 | 511 | 0.46 | 3,146 | 0.76 | 533 | 3,020 |
| 1991 | 3,485 | 1,107 | 72 | 274 | 0.25 | 4,036 | 0.59 | 419 | 2,642 |
| 1992 | 3,485 | 1,291 | 64 | 374 | 0.34 | 3,449 | 0.37 | 260 | 4,968 |
| 1993 | 3,485 | 106 | 56 | 218 | 0.20 | 487 | 0.22 | 153 | 694 |
| 1994 | 3,500 | 476 | 71 | 256 | 0.23 | 1,859 | 0.28 | 197 | 2,417 |
| 1995 | 3,500 | 3,564 | 60 | 443 | 0.40 | 8,050 | 0.39 | 274 | 12,991 |
| 1996 | 3,500 | 3,220 | 62 | 750 | 0.68 | 4,294 | 0.73 | 513 | 6,274 |
| 1997 | 5,250 | 5,235 | 70 | 841 | 0.76 | 6,745 | 0.85 | 601 | 8,715 |
| 1998 | 5,250 | 5,163 | 67 | 1,139 | 1.03 | 4,570 | 1.17 | 823 | 6,271 |
| 1999 | 8,750 | 5,132 | 71 | 976 | 0.88 | 5,237 | 0.97 | 681 | 7,535 |
| 2000 | 5,250 | 4,261 | 33 | 1,216 | 1.10 | 4,427 | 1.35 | 955 | 4,460 |
| 2001 | 8,750 | 6,023 | 39 | 1,104 | 1.00 | 5,362 | 1.00 | 705 | 8,540 |

1 TAC'S FOR 1989 AND 1990 ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30 AND FOR THE CALENDAR YEAR, THEREAFTER, MAKING 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31)
TAC'S AFTER 1996 MAY INCLUDE TRANSFERS FROM OTHER SECTORS.

2 CATCH (TONS) FOR 1988 AND 1989 AS REPORTED IN ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY AND FROM YEAR-END QUOTA REPORTS AND/OR LOGBOOK RECORDS, THEREAFTER.

3 PERCENT CATCH OBSERED IN CALENDAR YEAR AS REPORTED IN STANDARDIZED OBSERVER DATA CPUE DATASET.

4 EFFORT CALCULATED FROM OFFSHORE VESSEL OBSERVER DATA, SINGLE TRAWL, NO WINDOWS.

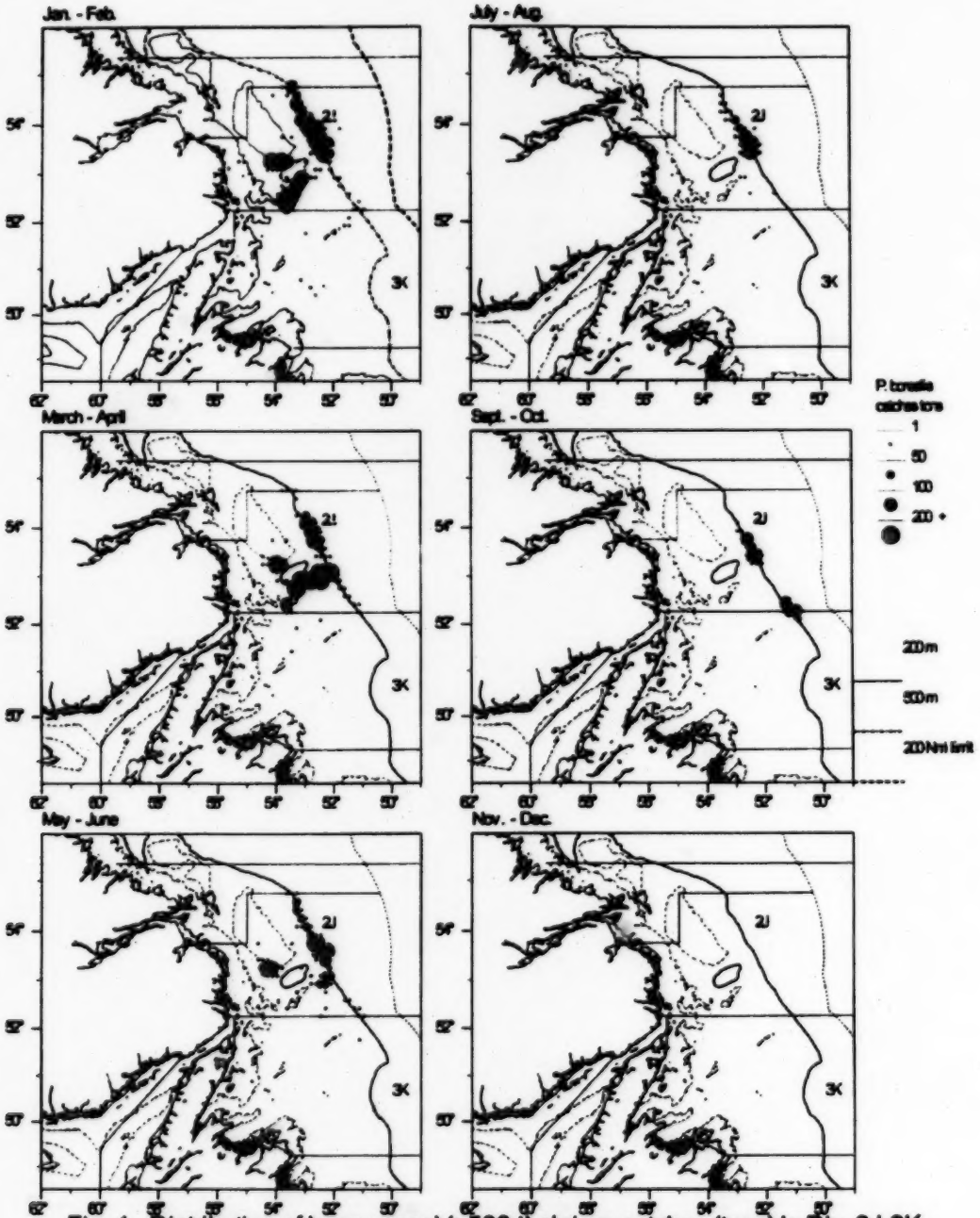



Fig. 1 Distribution of large vessel (>500 t) shrimp catches (tons) in Div. 2J-3K (SFA 6) during 2001. (Logbook data aggregated into 10 min. squares.)

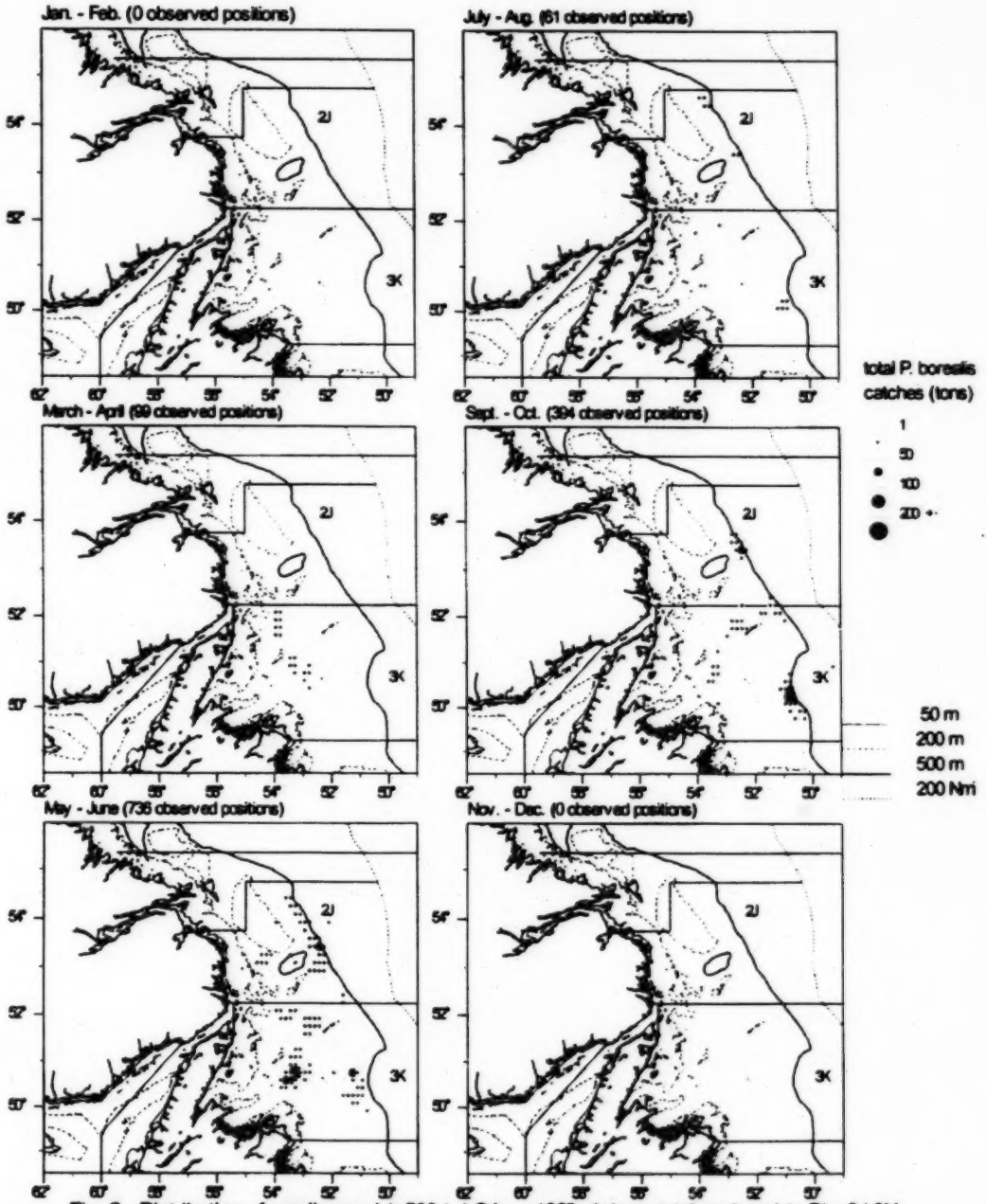



Fig. 2 Distribution of small vessel (<500 t; LOA <=100') shrimp catches (tons) in Div. 2J-3K (SFA 6) during 2001. (Observer data aggregated into 10 min. squares.)

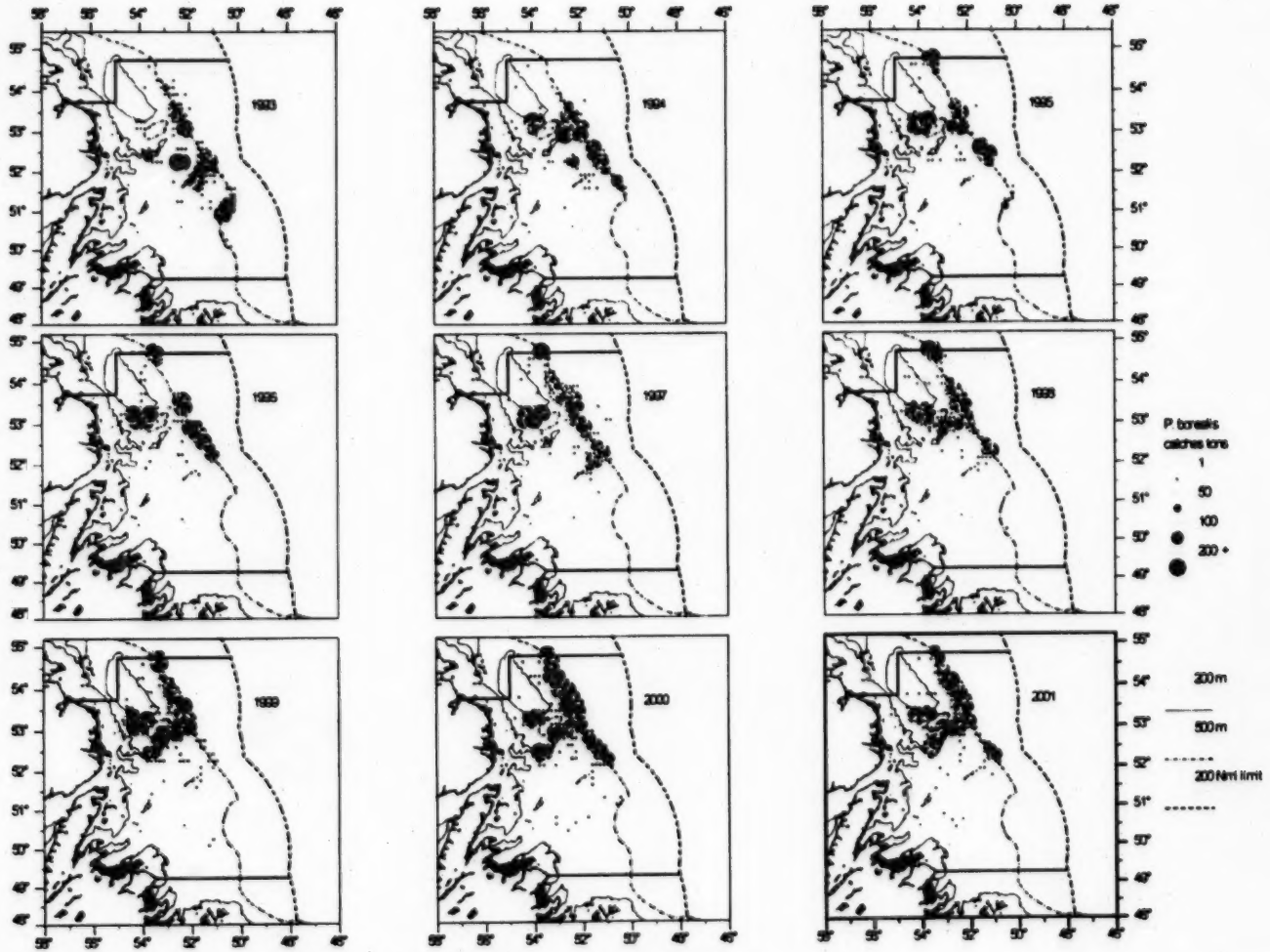



Fig. 3 Distribution of large vessel (>500 t) shrimp catches (tons) in Div. 2J-3K (SFA 6), 1993 - 2001.
(Logbook data aggregated into 10 min. squares.)

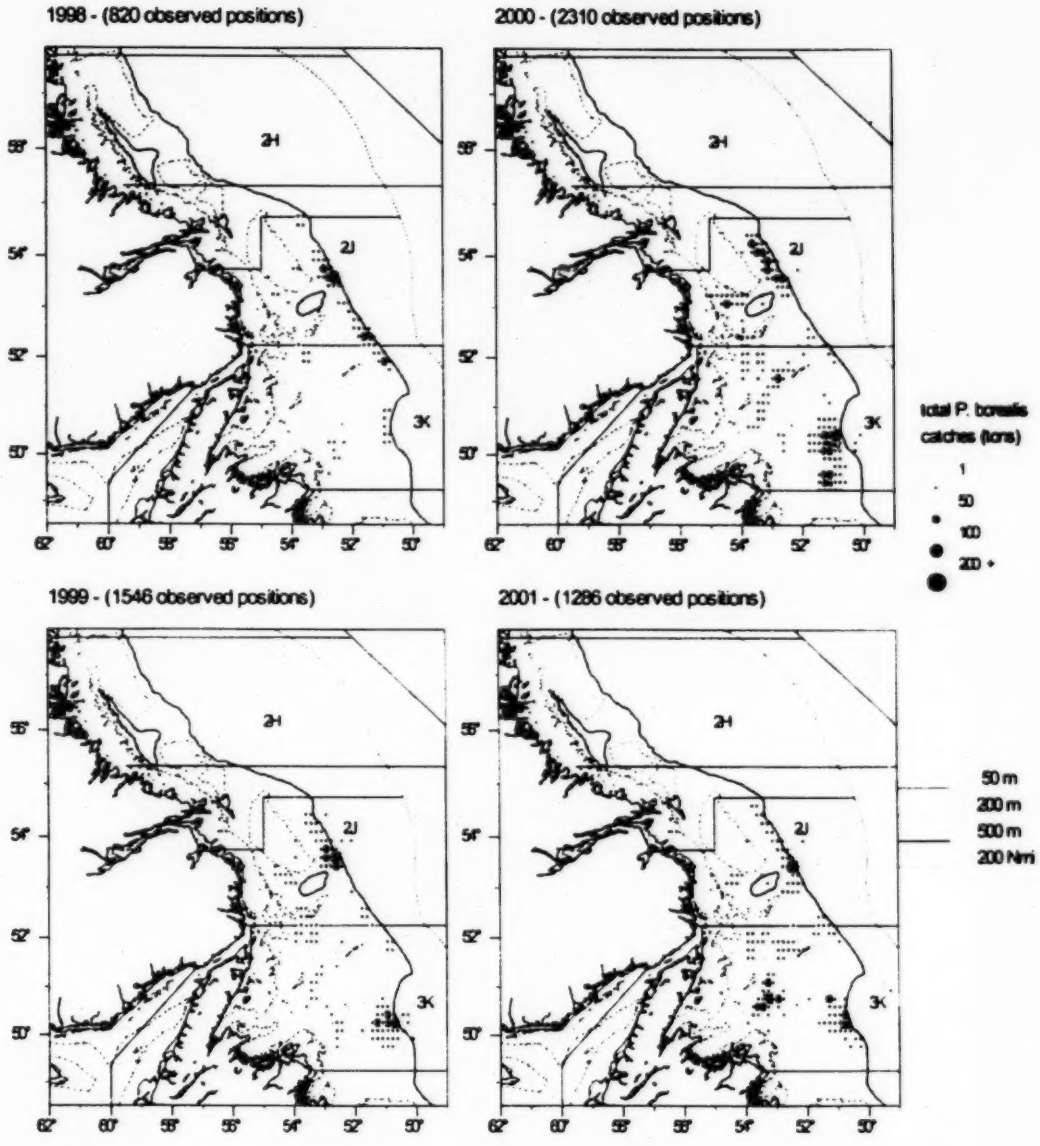



Fig. 4 Distribution of small vessel (<500 t; LOA <100') fishing effort in Div. 2J-3K (SFA 6), 1998 - 2001. (Observer data aggregated into 10 min. squares.)

Fig. 5 Standardized catch...numbers-per-hour...000s in NAFO Division 3K-2J (SFA 8), 1992-2001.
Solid line = Males, Broken line = Females.

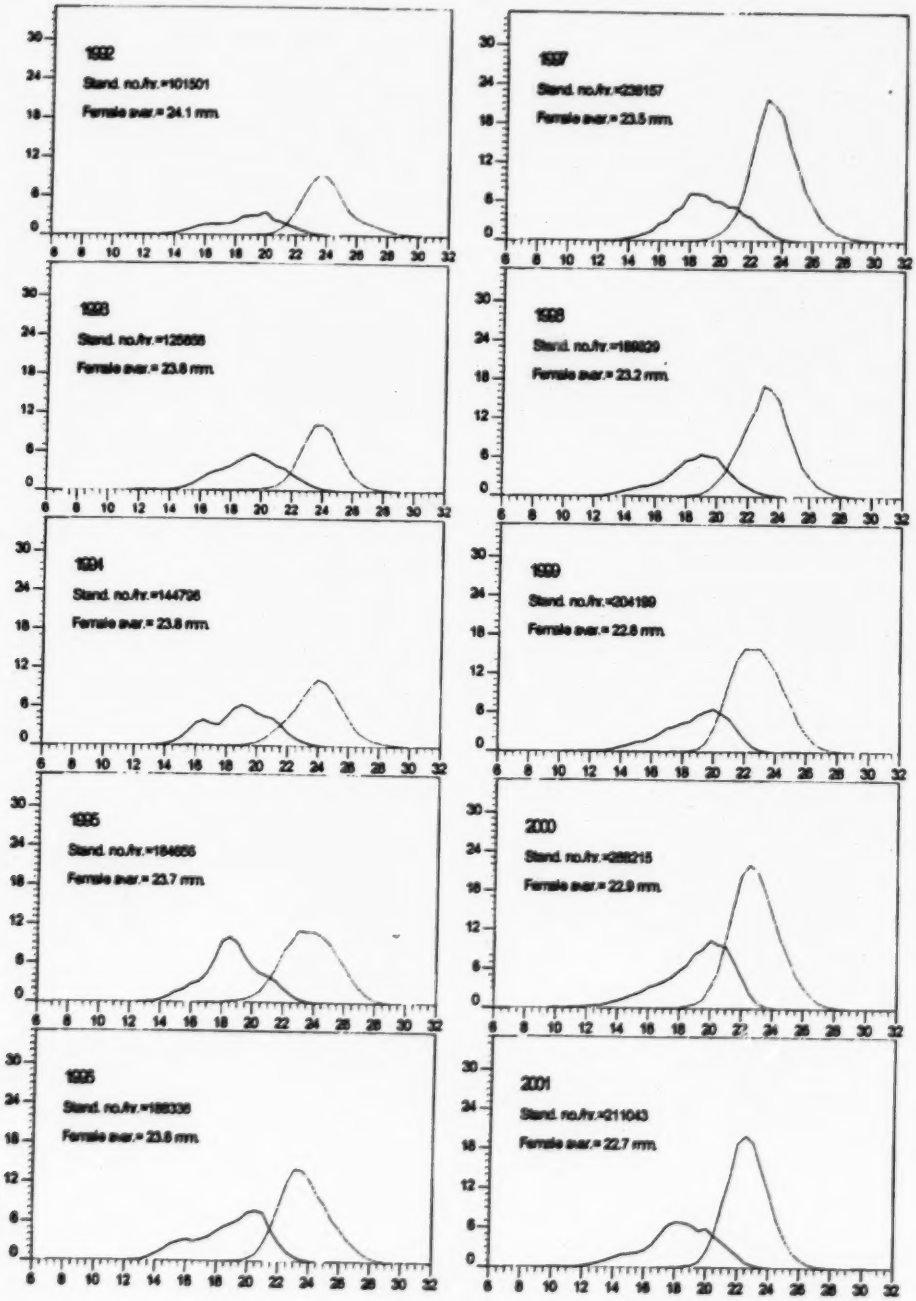
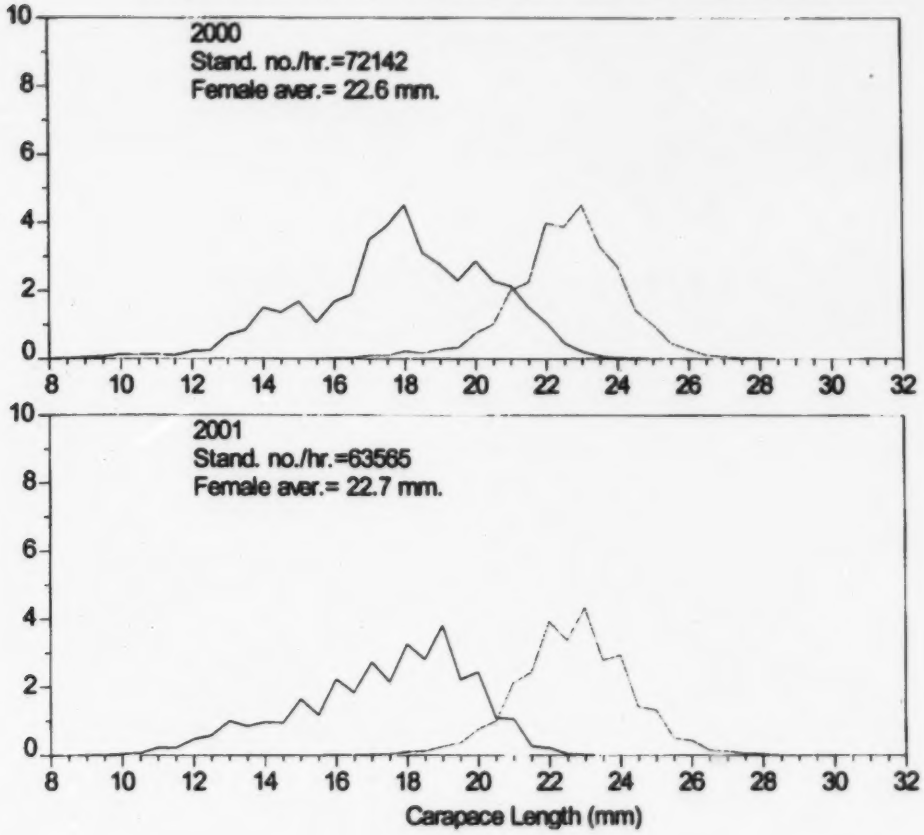


Fig. 6 Standardized catch ...numbers-per-hour..000s from small vessels, NAFO Division 3K-2J (SFA 6), 2000-2001. Solid line = Males, Broken line = Females.



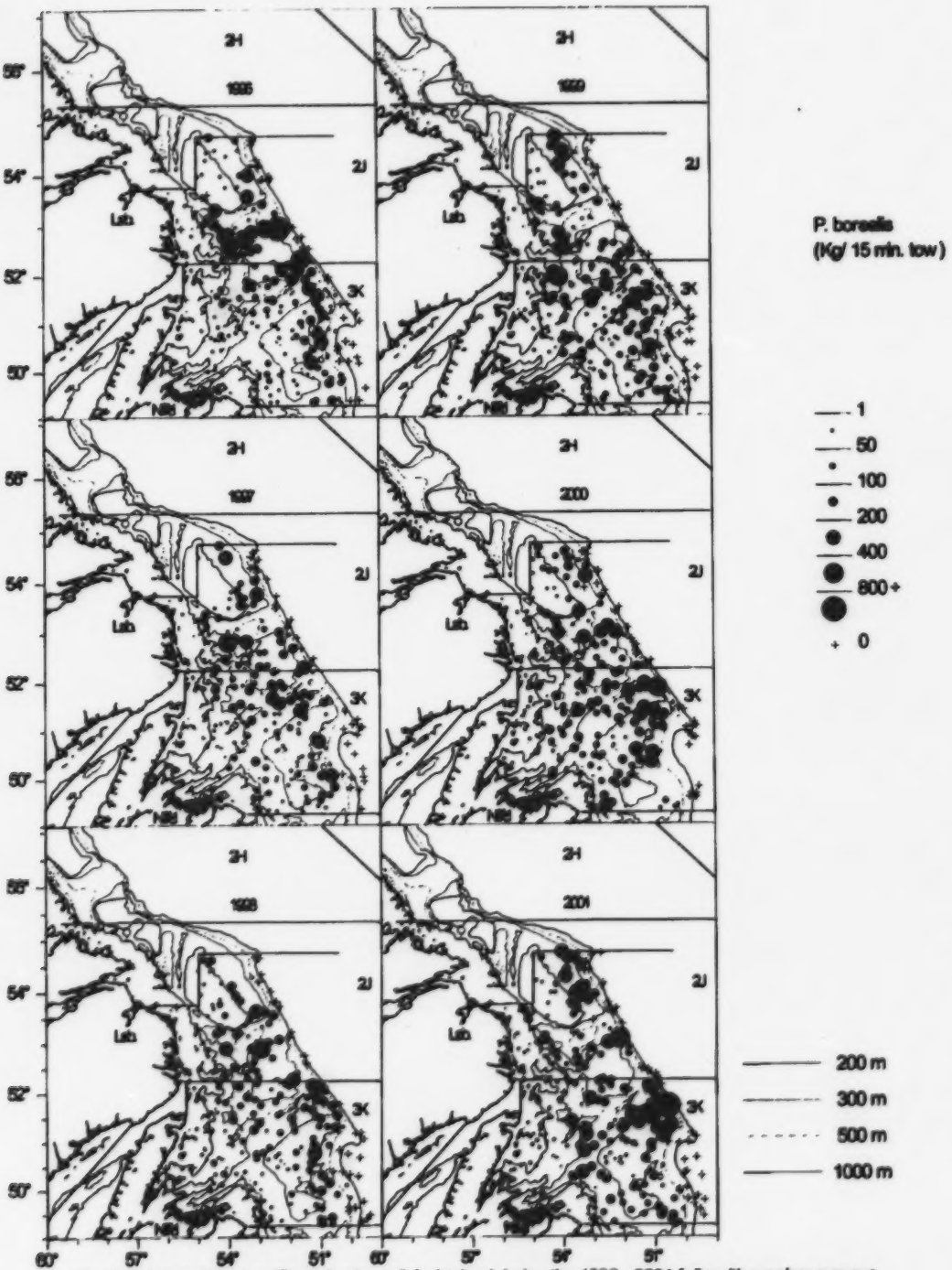



Fig. 7 Catches of shrimp (Pandalus borealis) obtained during the 1996 - 2001 fall multi-species surveys into Hawke Channel + 3K (SFA 6) using a Campelen 1800 shrimp trawl. (standard 15 min. tows)

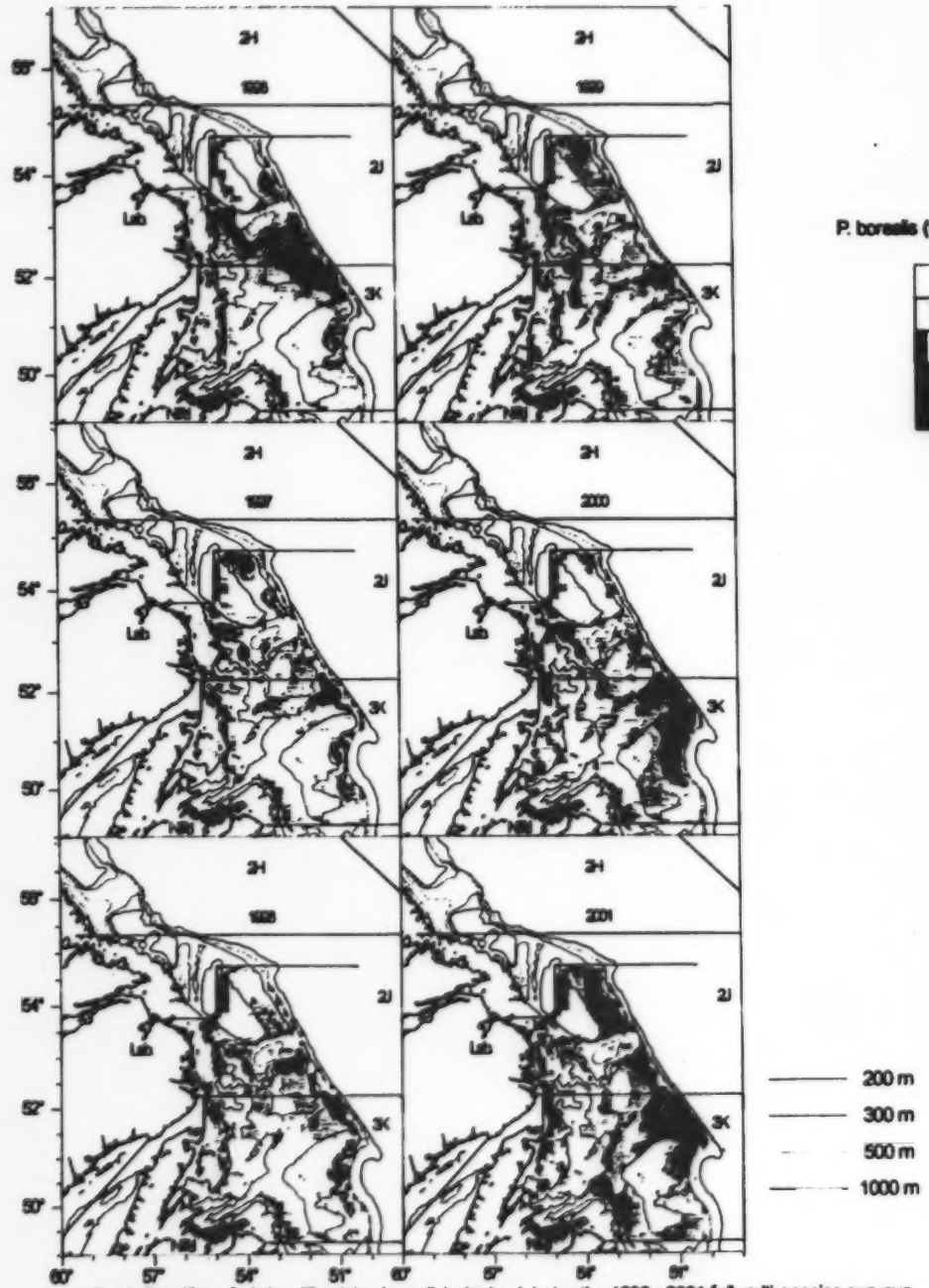



Fig. 8 Densities of shrimp (Pandalus borealis) obtained during the 1996 - 2001 fall multi-species surveys into Hawke Channel + 3K (SFA 6) using a Campelen 1800 shrimp trawl. (standard 15 min. tows)

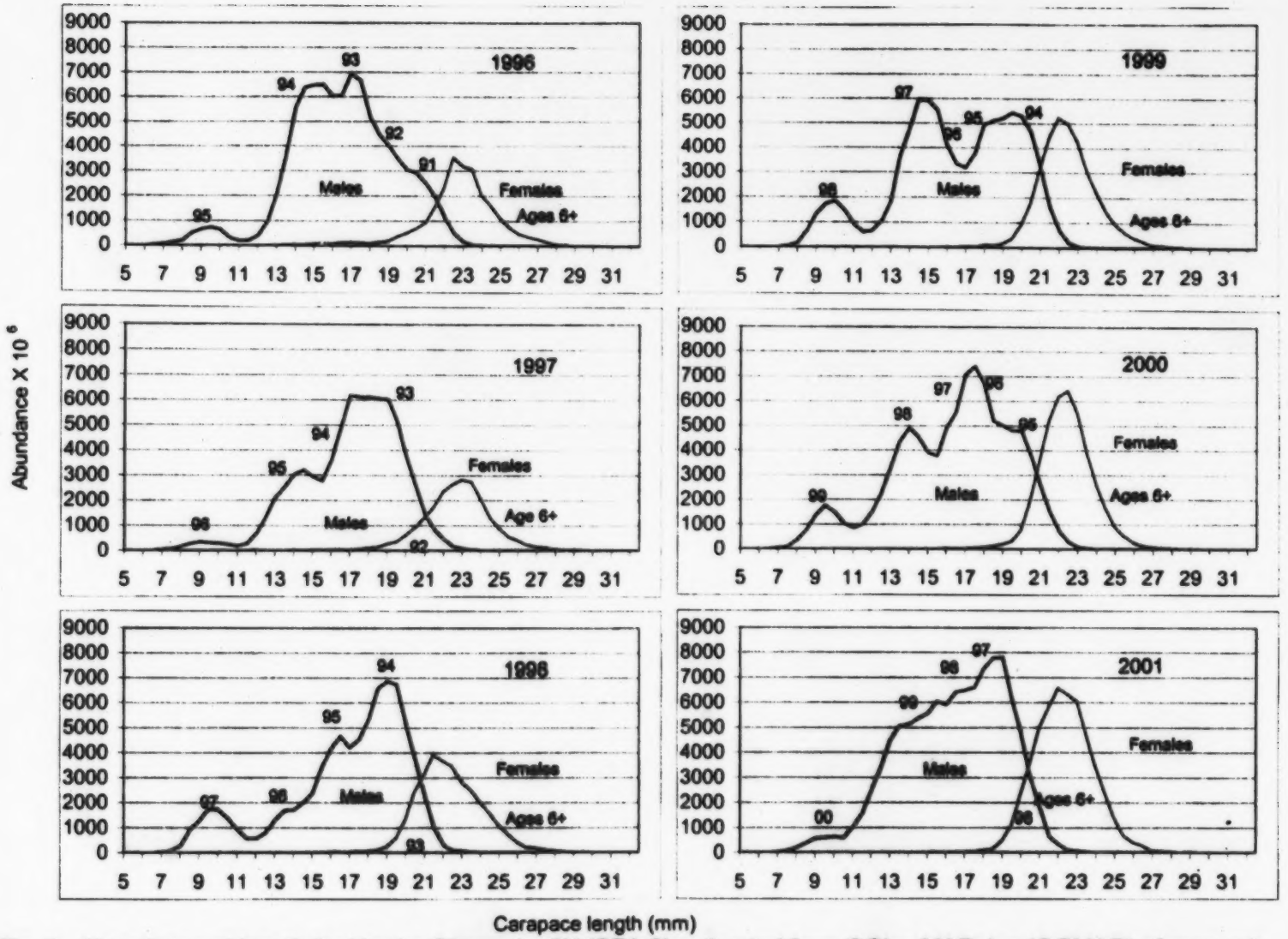



Fig. 9 Abundance at length for Hawke Channel + 3K (SFA 6) estimated from OGive MAPping (OGMAP) of research survey data, 1996 – 2001.

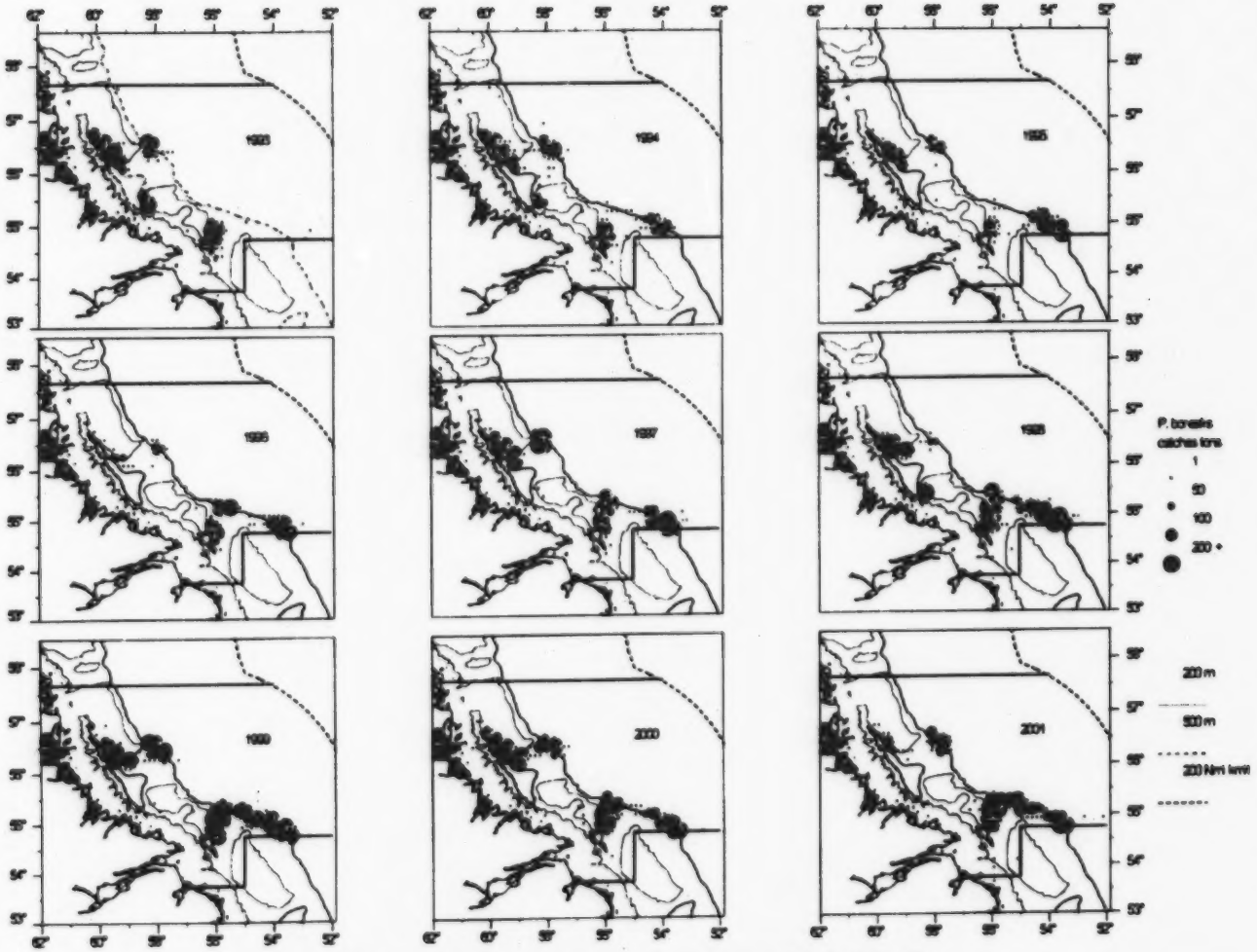



Fig. 10 Distribution of large vessel (>500 t) shrimp catches (tons) in Hopedale + Cartwright Channels (SFA 5), 1993 - 2001.
(Logbook data aggregated into 10 min. squares.)

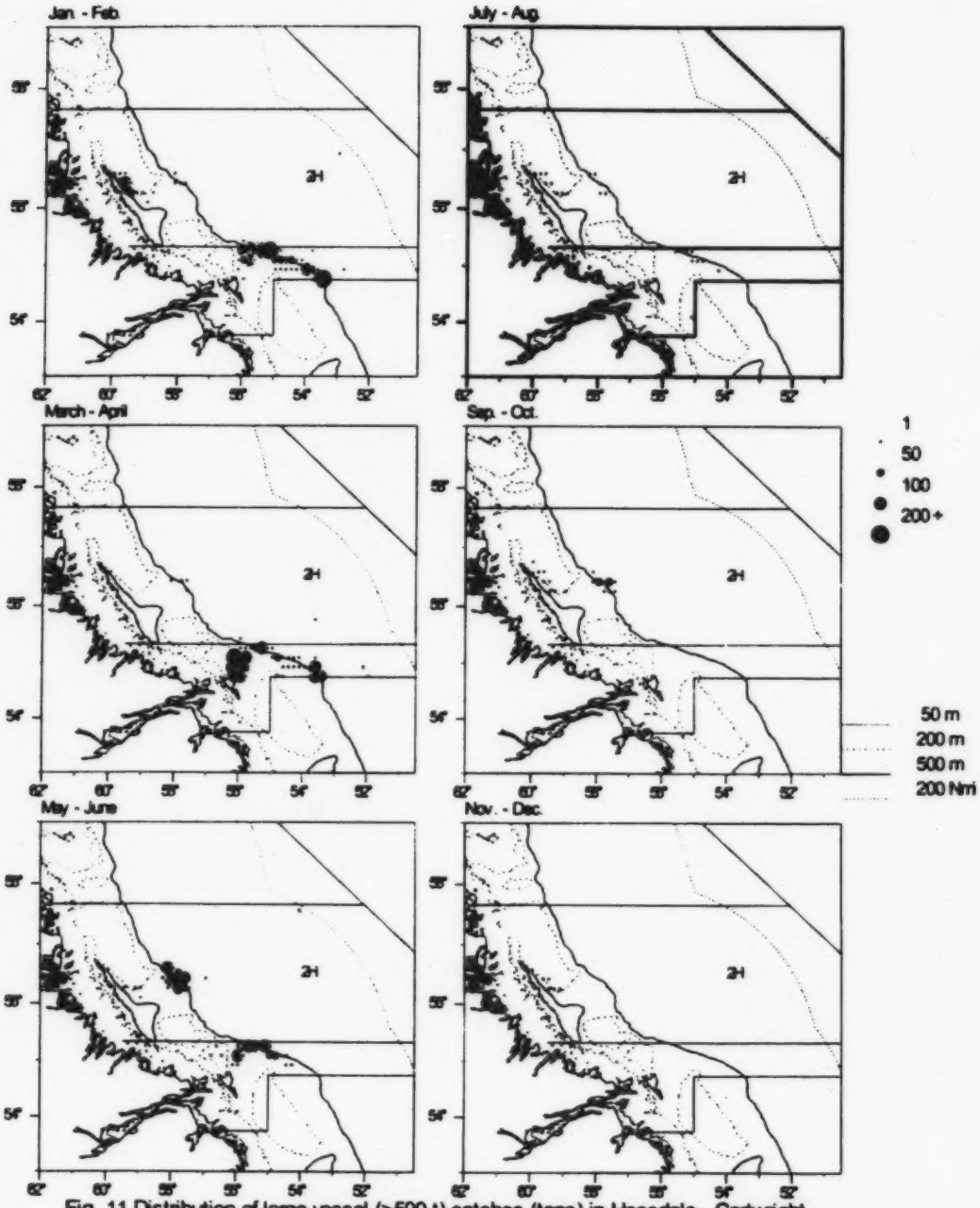
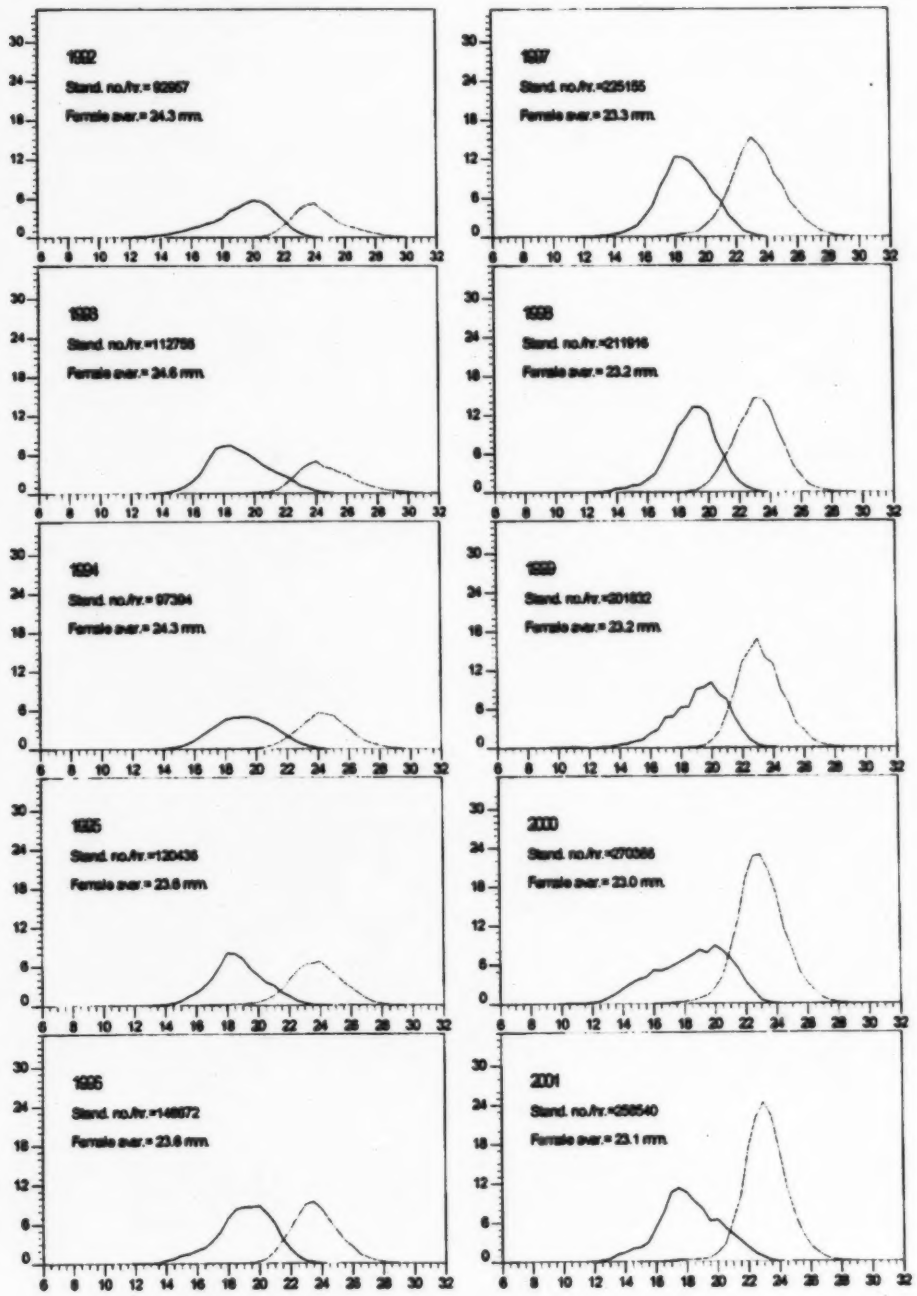



Fig. 11 Distribution of large vessel (>500 t) catches (tons) in Hopedale - Cartwright (SFA 5) during 2001. (Logbook data aggregated into 10 min. squares.)

Fig. 12 Standardized catch...numbers-per-hour...000s in NAFO Division 2+U (SFAs), 1992-2001.
Solid line = Males, Broken line = Females.



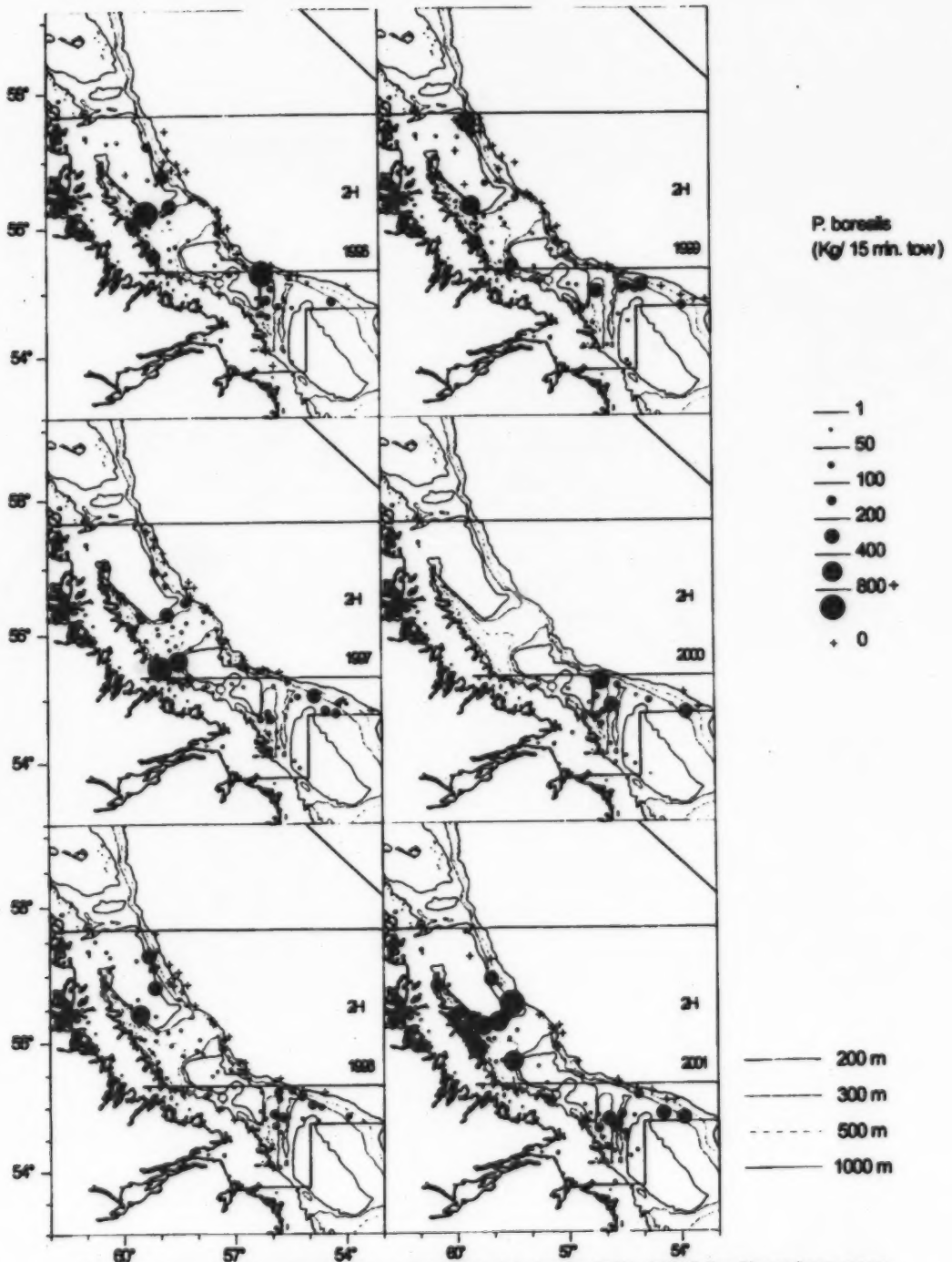



Fig. 13 Catches of shrimp (Pandalus borealis) obtained during the 1996 - 2001 fall multi-species surveys into Hopedale - Cartwright Channels (SFA 5) using a Campelen 1800 shrimp trawl (standard 15 min. tows)

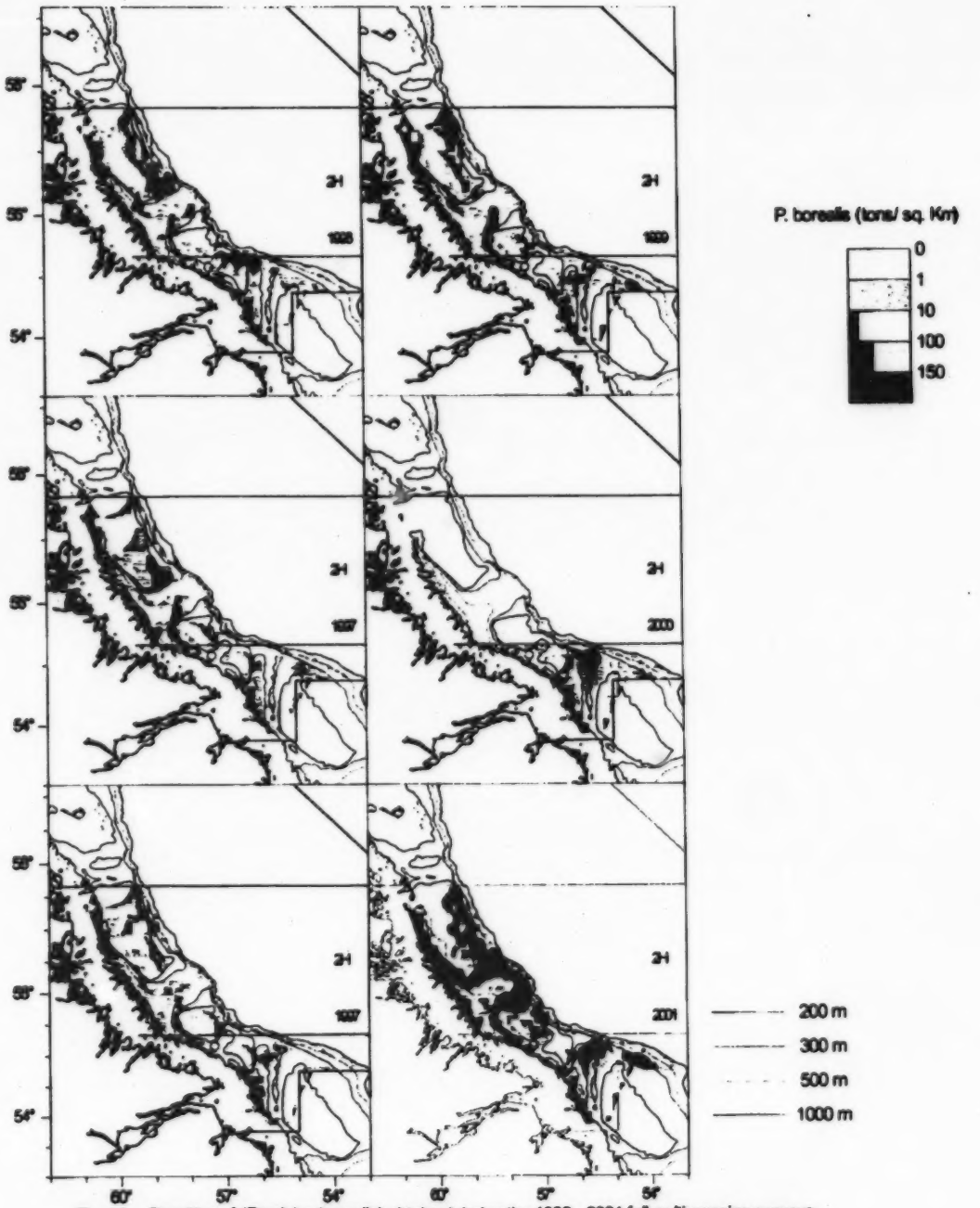



Fig. 14 Densities of (Pandalus borealis) obtained during the 1996 - 2001 fall multi-species surveys into Hopedale and Cartwright Channels (SFA 5) using a Campelen 1800 shrimp trawl. (standard 15 min. tows)

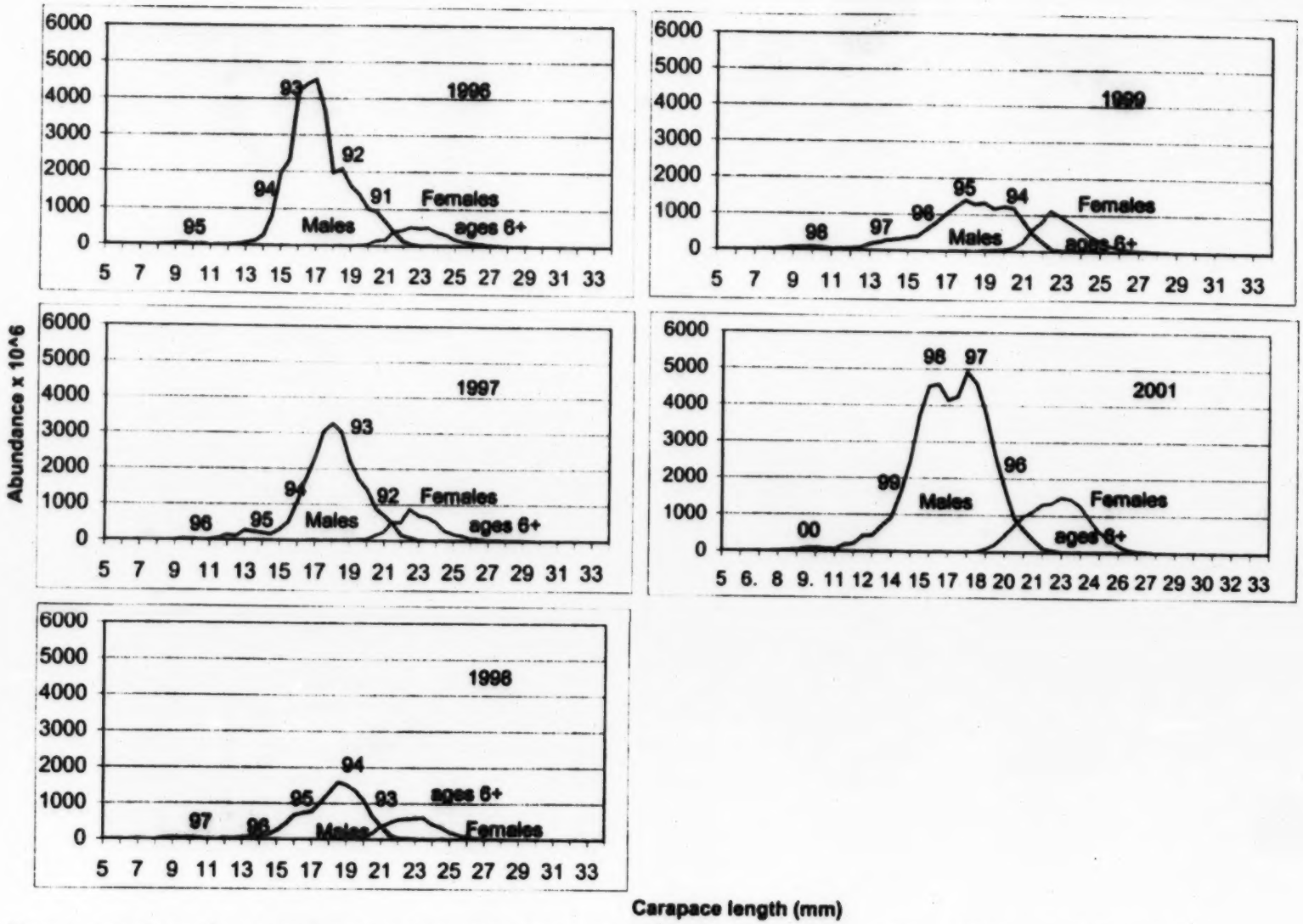



Fig. 15 Abundance at length for Hopedale + Cartwright Channels (SFA 5) estimated from OGive MAPping (OGMAP) of research survey data, 1996 – 2001.

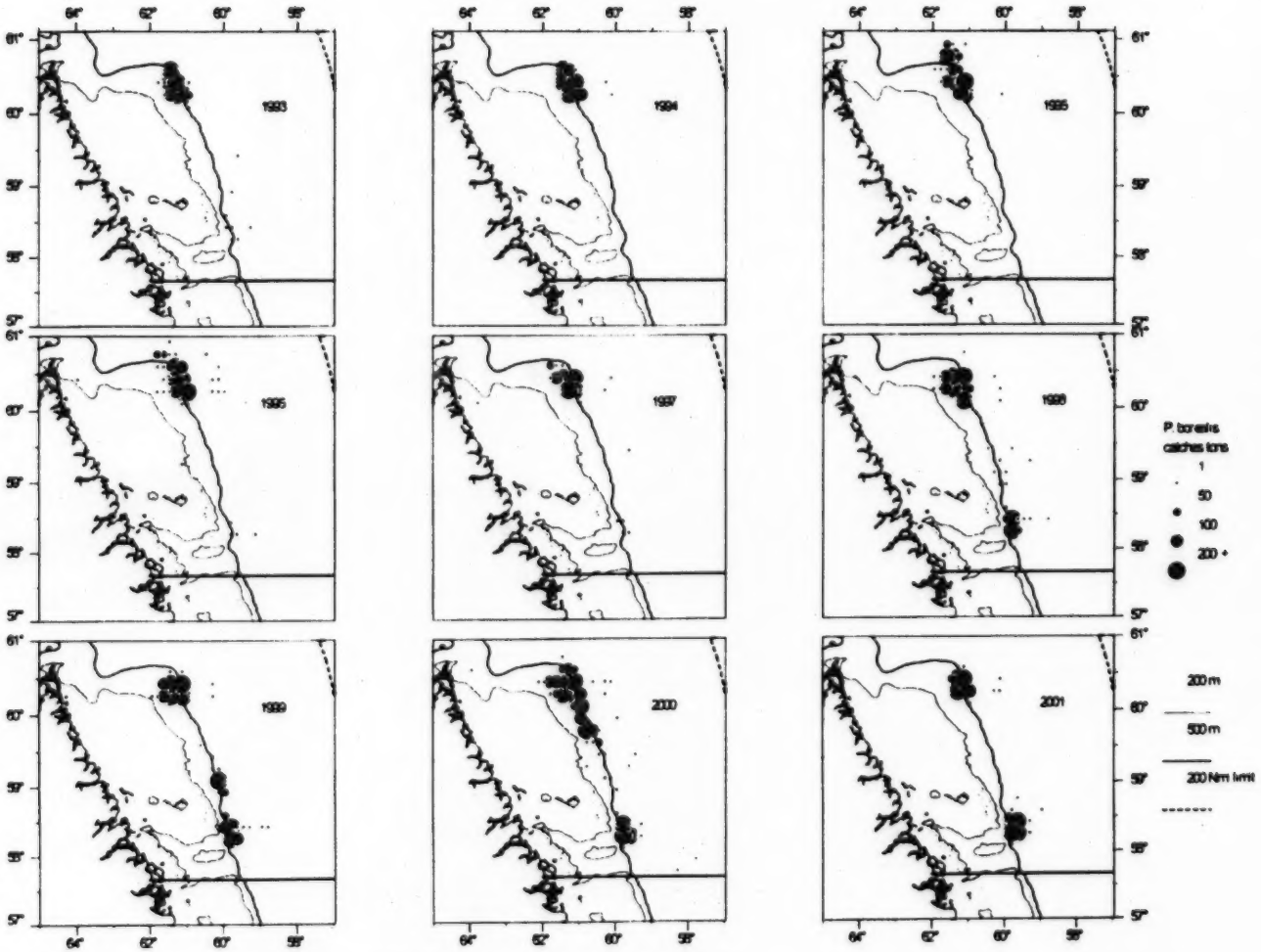



Fig. 16. Distribution of large vessel (>500 t) shrimp catches (tons) in Div. 2G (SFA 4), 1993-2001.
(Logbook data aggregated into 10 min. squares.)

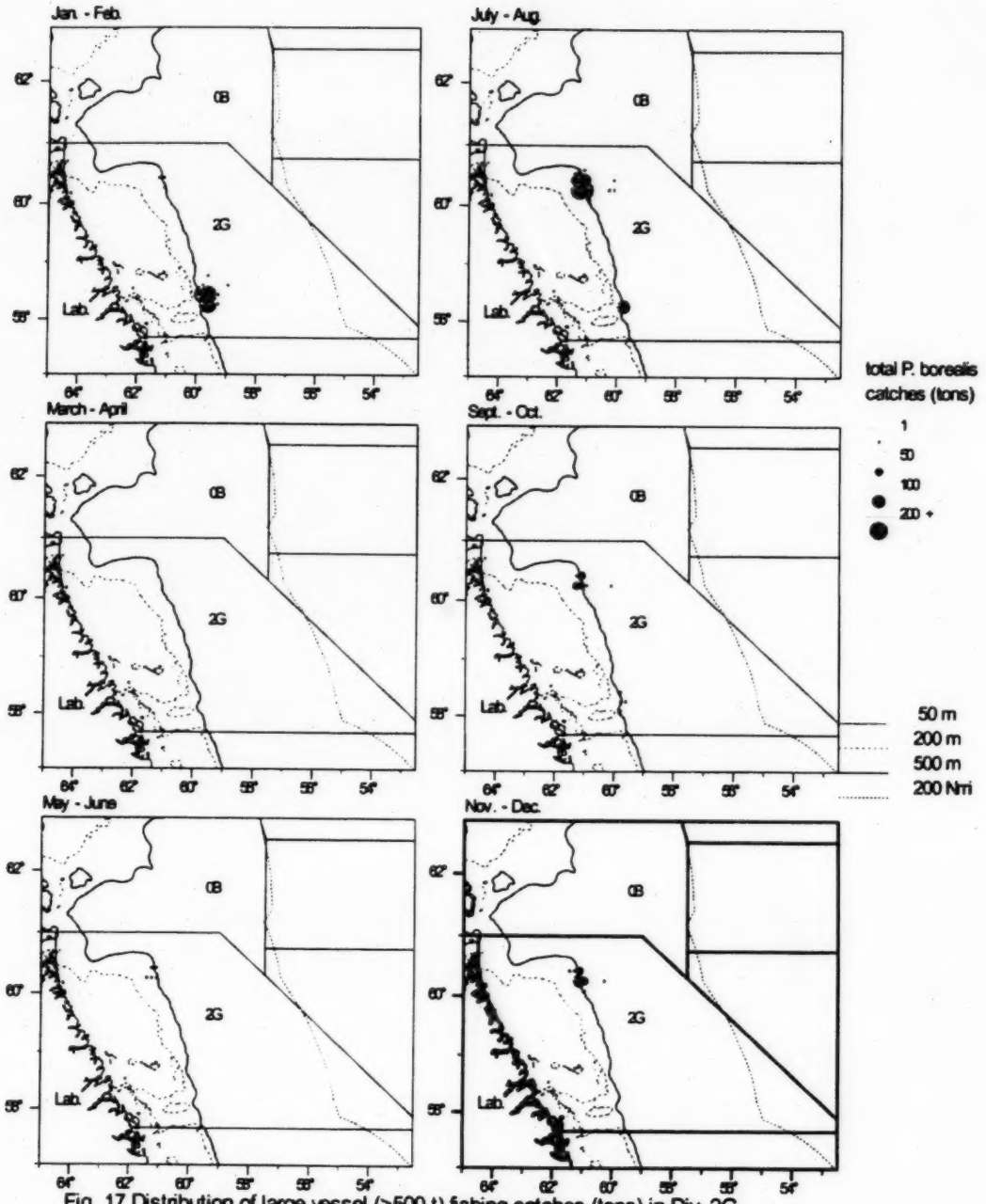
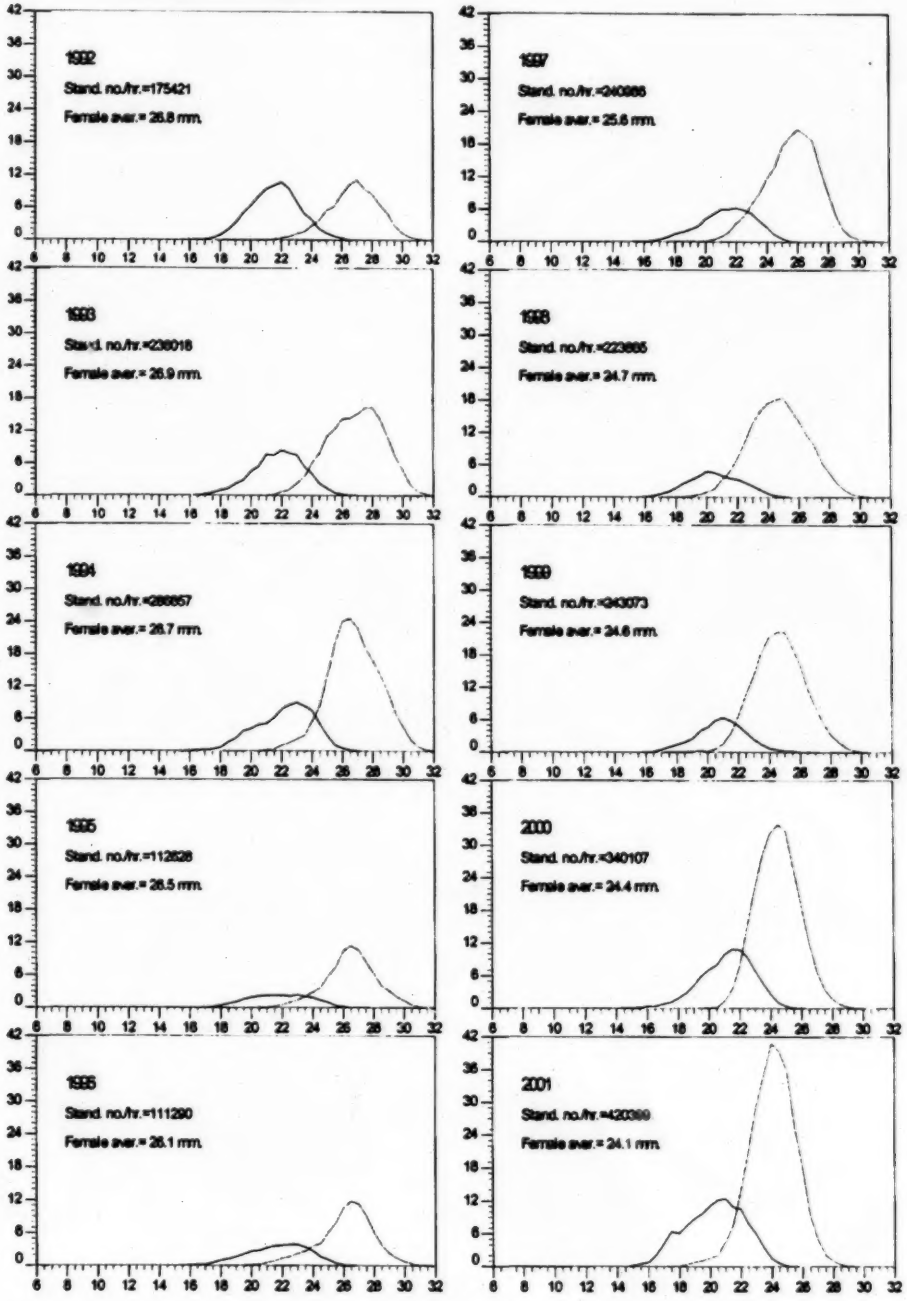



Fig. 17 Distribution of large vessel (>500 t) fishing catches (tons) in Div. 2G (SFA 4) during 2001 . (Logbook data aggregated into 10 min. squares.)

Fig. 18 Standardized catch...numbers-per-hour...000s in NAFO Division 2G (SFA 4), 1992-2001.
Solid line = Males, Broken line = Females.



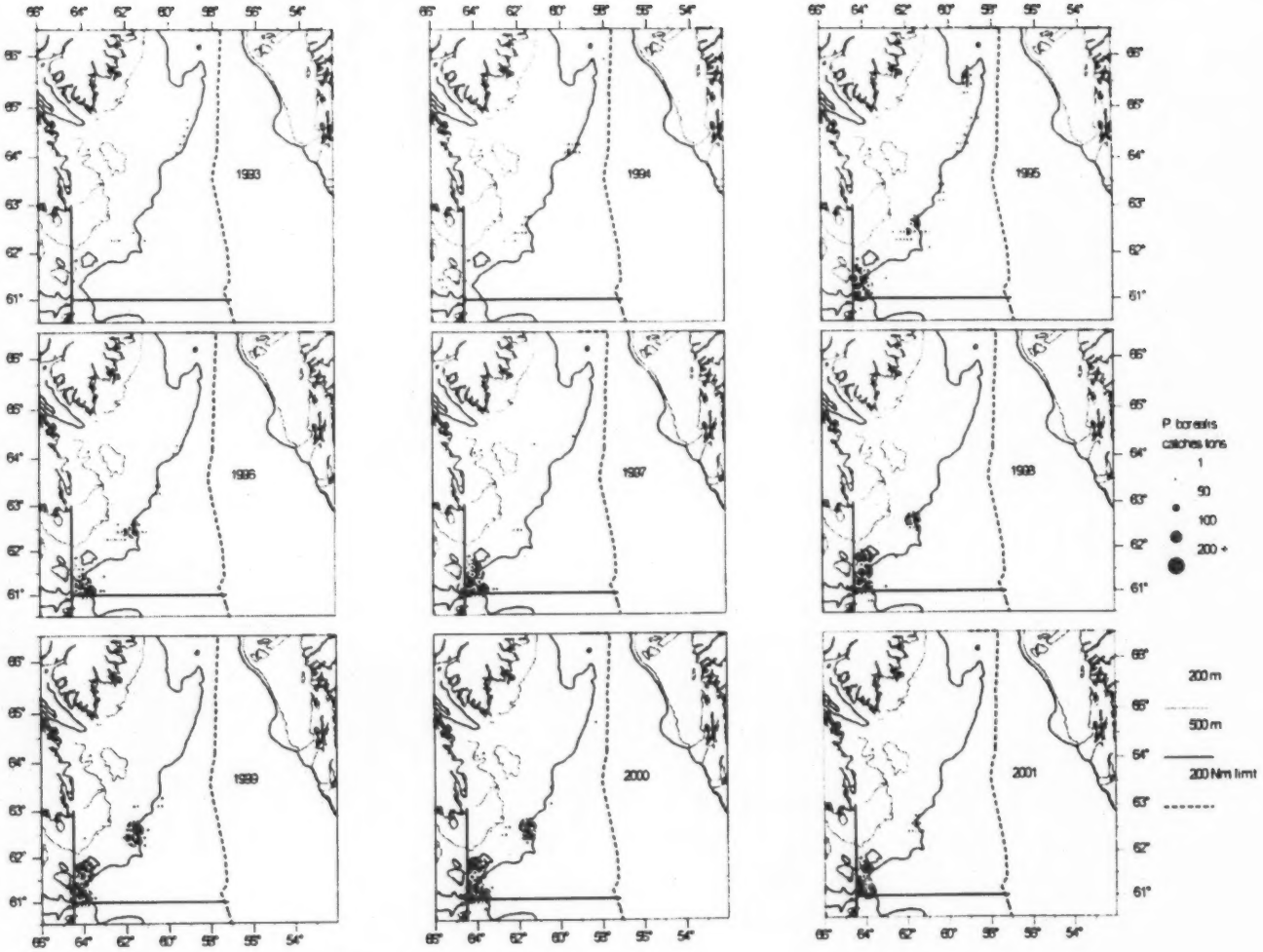



Fig. 19 Distribution of large vessel (>500 t) catches (tons) in Div. 0B (SFA 2), 1993-2001.
(Data aggregated into 10 min. squares.)

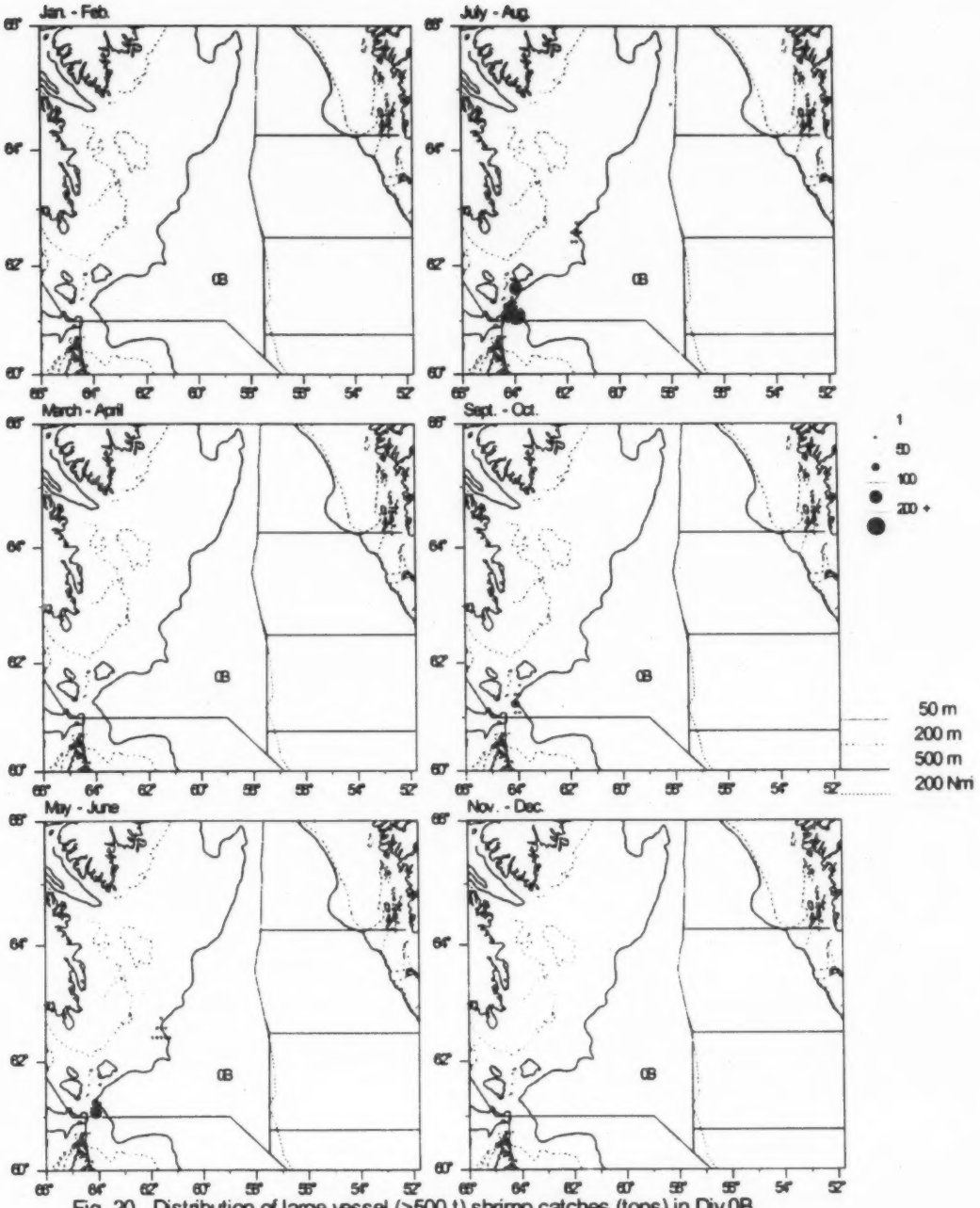



Fig. 20 Distribution of large vessel (>500 t) shrimp catches (tons) in Div 0B (SFA 2) during 2001. (Logbook data aggregated into 10 min. squares.)

Fig. 21 Standardized catch-per-hour (000s) in NAFO Division 0B (SFA 2), 1992-2001.
Solid line = Males, Broken line = Females.